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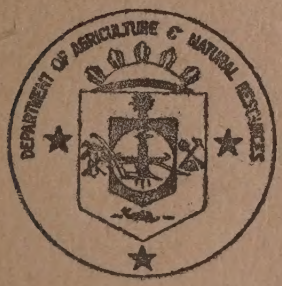

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THE GROSS MORPHOLOGY OF THE GAS BLADDERS OF SOME LAGUNA DE BAY FISHES [1]

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TEN TEXT FIGURES

INTRODUCTION

Gas bladder is a term with more universal acceptance than swim bladder or air bladder. The latter terms are misnomers in the sense that gas bladder is not really used for swimming nor the gases it contains are of the same proportion as the gases in air. The bladder is a hollow, retroperitoneal organ lying against the peritoneum ventrally and the kidneys dorsally. The bladder is an evagination either from the middorsal or lateral walls of the foregut. In some fishes the connection with the foregut still persists. In general, a pneumatic duct, the duct connecting the gas bladder to foregut, persists in soft-rayed fishes; in spiny-rayed fishes this duct is degenerated and the bladder loses its connection with the alimentary canal thus completely isolating it from the outside. Fishes with pneumatic ducts are called physostomous fishes, or physostomes; those without are the physoclistous fishes, or physoclists. Both terms, physostomous and physoclistous, can also be used to describe the gas bladders.

In the closed gas bladder of the physoclists, two glands are present which play a very important role in the secretion and absorption of gases in the bladder. They are an anteroventral secretory epithelium called the gas gland, with its associated *retia mirabilia*, or *rete mirabile*, and a posterodorsal resorbing epithelium called the oval gland (Jones, 1957). In physostomous gas bladder the gas and oval glands are present but their value as gas exchangers is considerably less since gases could be emptied into the alimentary canal through the pneumatic duct.

Historical examination of the gas bladders reveals structures, or layers, similar to that of the alimentary canal wall. However, modifications have occurred in most gas bladders. Fange

[1] This work was done in cooperation with the Freshwater Fisheries Investigations Unit of the Bureau of Fisheries in Los Baños, Laguna.

(1953) offered terminologies for use in the layers of the bladder wall. Fange and Wittenberg (1958) described the morphology of the two-chambered gas bladder of the toadfish, *Opsanus tau* L. Weinreb and Bilstad (1955) presented an account of the histology of physostomous gas bladder while Woodland (1911) studied the structures of the glandular epithelia.

Physiological studies of the secretion of gases in the bladder are quite puzzling due to an incomplete understanding of the ability of the gas gland to secrete gases against very high atmospheric pressure gradients. Scholander and Van Dam (1954) reviewed the theories of gas secretion. Scholander (1954) pointed out the checkerboard arrangement of capillaries in the *rete mirabile* and its counter-current exchange mechanism which may enable the gas gland to secrete gases against high pressure gradients. Wittenberg (1961) and Wittenberg and Wittenberg (1961) have thrown some light on cellular gas secretion although the problem of understanding its nature is far from complete.

One of the main functions, or possibly the main function, of the gas bladder is to serve the fish as a hydrostatic organ. The bladder regulates the density, or mass per unit volume, of the fish in such a way that it becomes equal to the density of the water medium. Jones (1951) gave a good account on this. When a fish moves from one depth to another, the fish has to compensate for changes in density caused by the increase, or decrease, of the gas bladder volume brought about by changes in pressure. If the fish goes deep in the water, the greater pressure against its body will decrease the volume of the gas bladder, and that of the fish as a whole, thereby increasing the density of the fish. In order that the fish can stay at the desired depth and not sink any farther, gas must be secreted into the bladder to maintain its normal mass per unit volume, or density. The reverse will be true if and when the fish ascends towards the surface. Less pressure from without against the body of the fish has the effect of increasing the volume of the gas bladder. To keep itself from floating at the very surface, the fish has to increase its density by partially resorbing the gas contents of its bladder.

In some fishes the gas bladder is reduced, or even absent, depending upon its importance to the fish as a hydrostatic organ. It is either reduced, or absent, in some stream-dwelling as well as in some bottom-dwelling fishes. Examples of such

fishes are the darters of North America (Morgan, 1956) which are mostly stream dwellers and some deep-sea fishes which stay permanently at the ocean bottom.

Besides serving as a hydrostatic organ, the gas bladder can serve as respiratory organ to lungfishes; bowfin, *Amia*; mudminnow, *Umbra;* garpikes, *Lepisosteus*; and other species. The presence of gas bladders functioning as lungs, particularly in lungfishes, lends credence to the theory that lungs are more primitive than gas bladders. The two organs, however, are considered homologous structures. The gas bladder may serve as a resonating organ too and the trigger fishes (Balistidæ) use it as such. Here sound is produced by the stridulation of the cleithrum against the postclavicles and the grating of the pharyngeal teeth with the gas bladder acting as a resonator (Jones, 1957). In some catfishes sound is produced when the bladder wall is vibrated by means of an elastic spring apparatus which is a modification of the transverse processes of the fourth vertebra (Jones 1957). In Ostariophysean fishes (Order Cypriniformes) high sound frequencies are heard because of the presence of Weberian ossicles connecting the gas bladder to the inner ear. Ordinarily, fishes respond to frequency range of 2000 to 3000 cycles per second but ostariophysean fishes can respond to frequencies of 7,000 to 10,000 cycles per second (Jones, 1957).

Usually, the gas bladder is a single-chambered organ but in some fishes it is two-chambered, or even three-chambered. In one fish, *Campostoma anomalum*, of the United States, the intestine is coiled around the gas bladder, making the condition a unique index for the identification of the species (Hubbs and Lagler, 1958). Familiarity with the anatomy of the gas bladder is a useful tool in the systematic studies of fishes. Dobbin (1941) correlated the gross morphology of bladders of fishes of New York to habitat and evolution (phylogeny).

This survey of the general morphology of the gas bladders of fishes in Laguna de Bay is undertaken to find out whether there exist certain peculiarities in the morphology, location, and shape of the gas bladders, and if so, to find means by which the morphology of the gas bladders of fishes studied could be made to jibe with the systematics, phylogeny, or the biology of any one group. This study is being undertaken with the hope of stimulating interests in our fishes, where much has yet to be done. It is aimed to follow this paper

with some histological and physiological studies of the peculiar gas bladders of some species.[1]

The fishes studied are the following:

Family Cyprinidae
1. *Cyprinus carpio* Linnaeus—Common carp.

Family Hemiramphidae (Halfbeaks)
1. *Hemiramphus georgii* Cuvier and Valenciennes—Non-spotted halfbeak.

Family Ophicephalidae
1. *Ophicephalus striatus* Bloch—Murrel, or snakehead, or *dalag.*

Family Anabantidae
1. *Anabas testudineus* (Bloch)—Climbing perch, or *liwalo,* or *martiniko.*
2. *Trichogaster trichopterus* (Pallas)
3. *Trichogaster pectoralis* (Regan)—*Pla-salid.*

Family Theraponidae
1. *Therapon plumbeus* (Kner)—Ayuñgin.

Family Clariidae
1. *Clarias batrachus* (Linnaeus)—Hito.

Family Cichlidae
1. *Tilapia Mossambica* Peters

Family Gobiidae
1. *Glossogobius giurus* (Hamilton-Buchanan)—*Biang-puti.*

MATERIAL AND METHODS

The fishes studied were collected from Laguna de Bay, namely, from Tanay, Rizal, representing the northern side and Los Baños, Laguna, on the southern side of the lake with the aid and cooperation of the Freshwater Fisheries Investigations Unit at Los Baños of the Bureau of Fisheries.[1] The work could not cover all the fishes of Laguna de Bay due to difficulties of obtaining desired specimens of the other species. However, the author believes that the fishes included here constitute the preponderant forms in the lake with the Family Anabantidae represented by three species.

The report confines itself to studies of the general morphology of the bladders, but details are left out for the time being. The aspects taken into consideration are the shape, size, location, and presence of any macrogland, and peculiarities or even uniqueness of bladders not usually following the normal morphological features.

[1] The author greatly appreciates the help extended by the personnel of the Bureau of Fisheries particularly that of Dr. Herminio R. Rabanal, Mr. Pedro A. Acosta, and Mrs. Medina N. Delmendo.

RESULTS

General descriptions of the gas bladders of the different fishes are given in order according to their proper systematic arrangement based on Herre (1953). Illustrations of position, shape, and size of the gas bladders are shown (figs. 1 to 10) to help understand the descriptions. The illustrations are diagrammatic; but they approximate the actual position, shape, and size of the bladders. Specimens were diagrammed to actual sizes.

1. *Cyprinus carpio* Linnæus (Fig. 1):

Location—bladder is retroperitoneal in position, ventral to the kidneys and dorsal to the peritoneum.

Morphology—The gas bladder is two-chambered with an interchamber duct between the anterior and posterior chambers. The interchamber duct allows shuttling of gases in both chambers. The pneumatic duct connects the antero-ventral region of the posterior chamber to the esophagus.

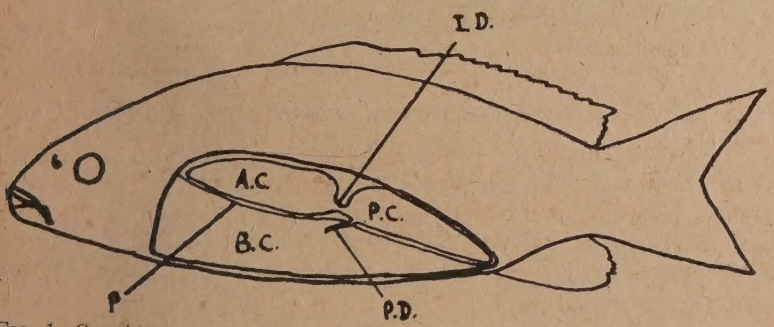

FIG. 1. *Cyprinus carpio* Linn. with its gas bladder shown at side view. A. C., anterior chamber of the gas bladder; B. C., abdominal cavity; I. D., interchamber duct; P, peritoneum; and P. C., posterior chamber.

The gas bladder extends the entire length of the abdominal cavity with a volume about half as much as the volume of the abdominal cavity. The anterior chamber is a little shorter than the posterior chamber and does not taper posteriorly like the latter. The anterior end is rounded and the posterior end more or less blunt. The wall of the anterior chamber is thinner and more transparent as contrasted with the wall of the posterior chamber which is quite opaque and appears silvery.

Gland—Almost the entire dorsal region of the anterior chamber is provided with a white thickened area which could possibly be a gland.

2. *Hemiramphus georgii* Cuvier and Valenciennes (Figs. 2A and 2B):

Location—The gas bladder occupies the dorsal portion of the abdominal cavity; retroperitoneal and ventral to the kidneys.

Morphology—The gas bladder is one-chambered and physostomous; the pneumatic duct connects with the anterior portion of the stomach (very near the esophagus). The bladder wall is thin and transparent. The posterior end of the bladder is rounded; anterior end somewhat pointed at the dorsal region where the pneumatic duct joined.

Gland—No gland is visible to the naked eye.

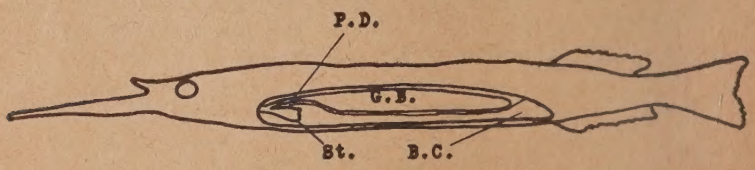

FIG. 2A. The side view of *Hemiramphus georgii* Cuv. & Val. and its gas bladder. B. C., abdominal cavity; G. B., gas bladder; P. D., pneumatic duct; and St., stomach.

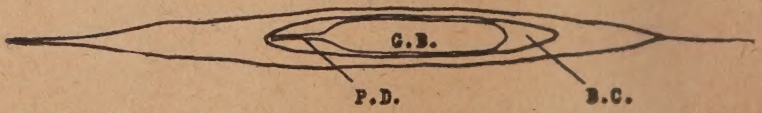

FIG. 2B. Ventral view of *H. georgii* Cuv. & Val. showing the gas bladder.

3. *Ophicephalus striatus* Block (Figs. 3A and 3B):

Location—The gas bladder is somewhat in the tail region of the fish. The anterior portion of the bladder is dorsal to the abdominal cavity.

Morphology—Possesses a single-chambered gas bladder; the posterior end of which is blunt with a small orifice near the center of the end, suggesting that gases in the bladder can escape into a space posterior to the bladder. This space is provided with a very thin membrane which is joined to the

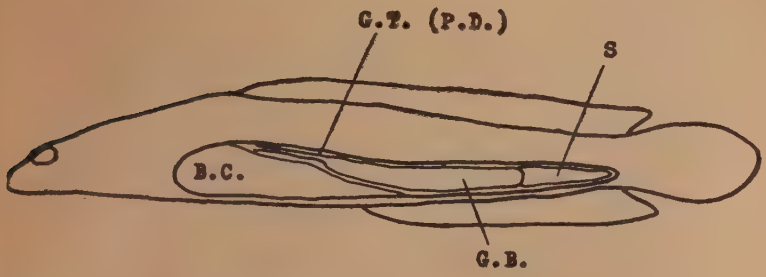

FIG. 3A. Side view of *Ophicephalus striatus* Bloch showing location and shape of the gas bladder. B. C., abdominal cavity; G. B., gas bladder; G. T., glandular tissue; P. D., pneumatic duct; and S, space.

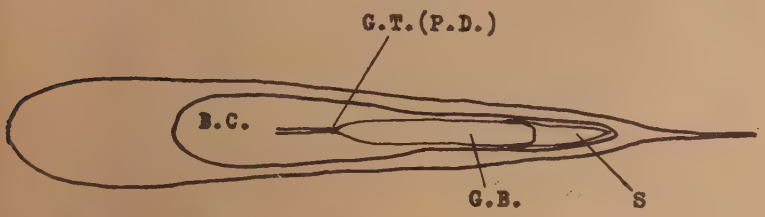

FIG. 3B. Ventral view of *O. striatus* Bloch and its gas bladder.

bladder wall. The bladder is a little bit pointed anteriorly. The bladder is surrounded by a thin lining.

The anterior end of the bladder is approximately 1.5 cm. craniad of the vent extending posteriorly almost to the caudal peduncle and ventral to the posterior portions of the kidneys. A space at the tail region accommodates the bladder in the tail region except for a portion 1.5 cm. long at the very posterior end. The specimen described is about 16.5 cm. long (total length). The space at the tail region wherein the gas bladder fits is retroperitoneal too as indicated by the peritoneal lining separating it from the abdominal cavity. A thin membrane surrounds the bladder and adheres to the bladder wall. It also bounds the space in the tail region wherein no bladder is located. There is therefore no chance for the gases that enter the space thru the orifice at the posterior end of the bladder to escape. Obviously the space is a part of the bladder.

Gland—A small, whitish gland is present at the anterior end of the bladder.

4. *Anabas testudineus* (Bloch) (Figs. 4A and 4B):

Location—The position of the gas bladder is unique due to its extension to the tail region up to the caudal peduncle. The bladder is retroperitoneal and ventral to portions of the kidneys. It is located above, or dorsal to, the interhaemal spines of the anal fin.

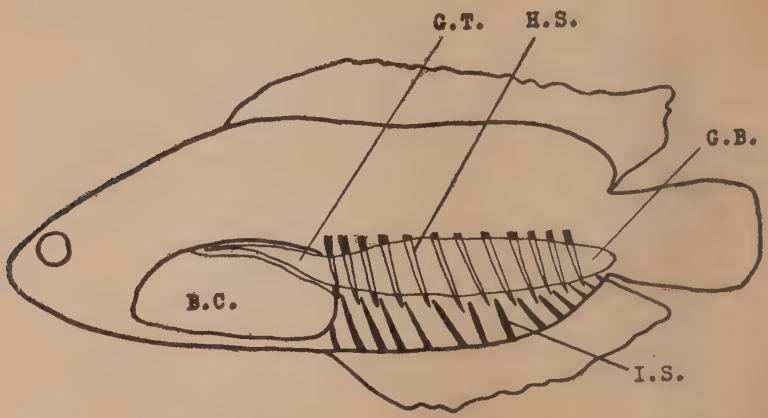

FIG. 4A. Lateral view of *Anabas testudineus* (Bloch) with the gas bladder shown. B. C., abdominal cavity, G. B., gas bladder, G. T., glandular tissue; H. S., haemal spine; I. S., interhaemal spine.

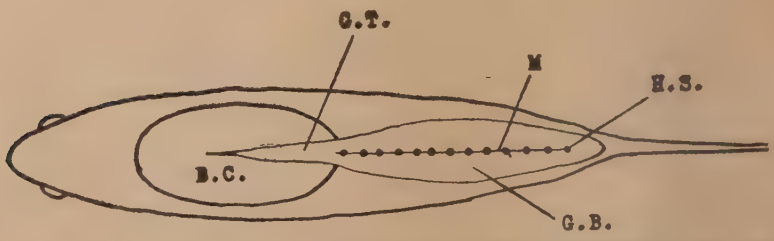

FIG. 4B. Ventral view of *A. testudineus* (Bloch) showing the gas bladder. M, interhaemal membrane.

Morphology—Anteriorly the bladder extends to about the middle portion of the abdominal cavity where it tapers to a point. Its wall is made up of a tough membrane. An extraordinary feature of the gas bladder is the presence of a par-

tition dividing the bladder into longitudinal halves. The partition is made up of a haemal spines alternating with tough interhaemal membranes that separate the left and right halves of the bladder at the tail region. For convenience, the partition will be designated interbladder septum. The partition of the bladder is incomplete due to the inability of the interbladder septum to proceed anteriorly into the portion of the bladder which is dorsal to the body cavity and the absence of haemal spines at the posterior region.

Gland—Glandular tissue is evident at the antero-ventral portions of the bladder. A blood vessel from the coeliacomesenteric artery supplies this gland.

5. *Trichogaster trichopterus* (Pallas) (Figs 5A and 5B):

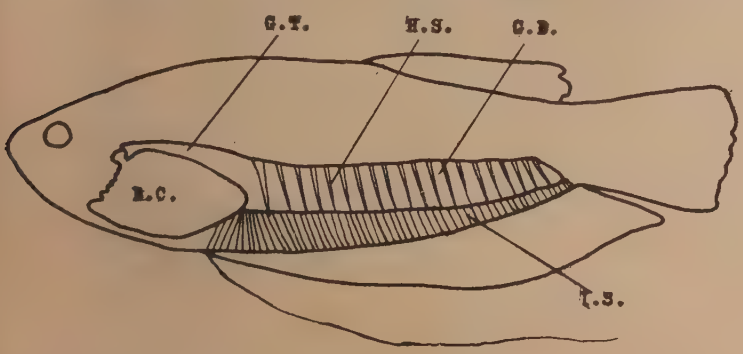

Fig. 5A. Side view of *Trichogaster trichopterus* (Pallas) showing the gas bladder. B. C., abdominal cavity; G. B., gas bladder, G. T., glandular tissue; H. S., haemal spine, and I. S., interhaemal spine.

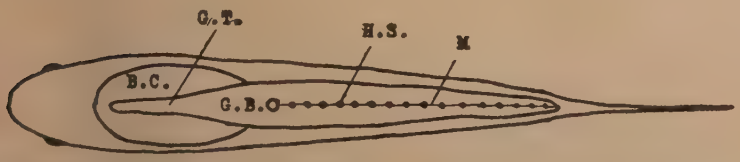

Fig. 5B. Ventral view of *T. trichopterus* (Pallas) and its gas bladedr. M, membrane between interhaemal spines.

Location—The bladder extends posteriorly up to the caudal peduncle; anteriorly a portion imposes itself dorsally upon the abdominal cavity. This anterior projection is about ⅓ the total length of the whole gas bladder.

Morphology—The gas bladder is single-chambered; divided longitudinally into left and right halves by an interbladder septum. The division is incomplete because of the absence of an interbladder septum at the anterior portion of the bladder. Although the fish is physoclistous there is still the possibility of the presence of a vertigial pneumatic duct.

Gland—Glandular tissue is evident at the antero-ventral portion of the bladder.

6. *Trichogaster pectoralis* (Regan) (Figs. 6A and 6B):

Location—The bladder is confined to the tail region and does not extend over the body cavity. Like *Anabas testudineus* and *T. trichopterus* the bladder is situated dorsal to the interhaemal spines of the anal fin.

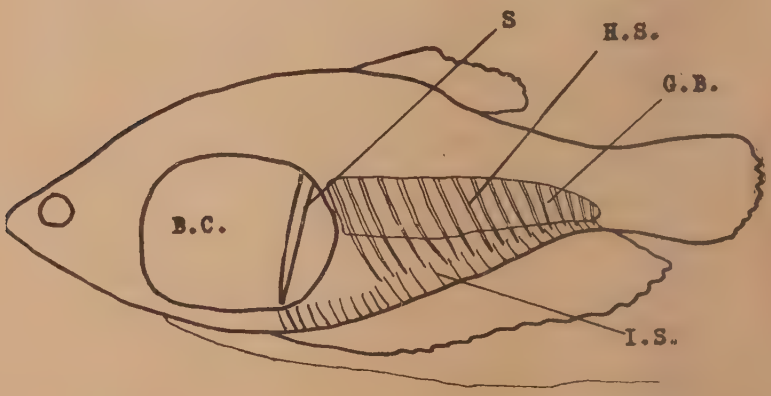

FIG. 6A. Side view of *Trichogaster pectoralis* (Regan) showing its gas bladder. B. C., abdominal cavity; G.B., gas bladder; H.S., haemal spines; I.S., interhaemal spine; and S. spine.

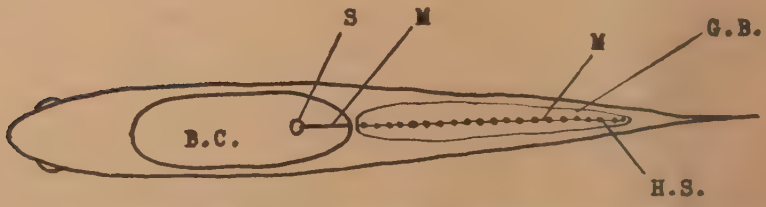

Fig. 6B. Ventral view of *T. pectoralis* (Regan) with its gas bladder shown. M, interhaemal membrane.

Morphology—The gas bladder is single-chambered externally and physoclistous. An interbladder septum completely divides the bladder into two longitudinal halves. The extent of the gas bladder is from the very posterior end of the abdominal cavity to the caudal peduncle of the tail region.

Gland—There is a semblance of a glandular tissue at the antero-ventral region of the bladder.

7. *Therapon plumbeus* (Kner) (Figs. 7A and 7B):

Location—The gas bladder is dorsal to the abdominal cavity and ventral to the kidneys, covered ventrally by the peritoneum.

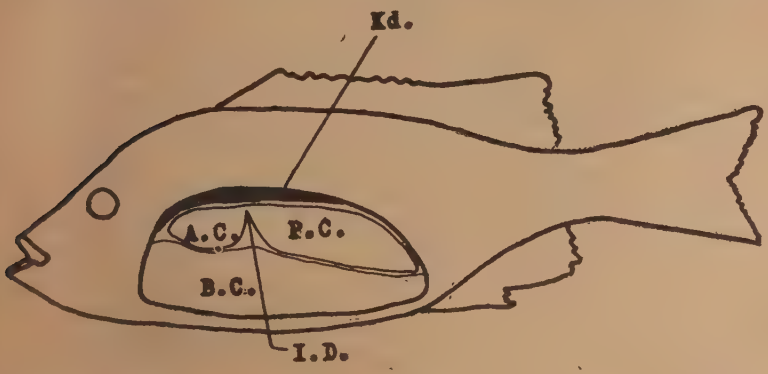

FIG. 7A. Lateral view of *Therapon plumbeus* (Kner) showing the shape and position of the gas bladder. A.C., anterior chamber of the gas bladder; B.C., abdominal cavity; I.D., interchamber duct; Kd. kidneys; and P.C., posterior chamber of the gas bladder.

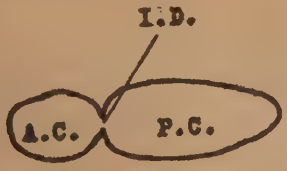

FIG. 7B. Ventral view of the gas bladder of *T. plumbeus* (Kner).

Morphology—There is a two-chambered gas bladder in this fish with an interchamber duct joining the two chambers. The interchamber duct is covered with adipose tissue, hence, obscure from view. Chambers intercommunicate with one another thru the interchamber duct. The anterior chamber is shorter

of the two, which is about ½ the length of the posterior chamber. Although the posterior chamber tapers a little bit posteriorly, its terminal end is rounded. The volume of the gas bladder is less than half the abdominal cavity volume but the gas bladder itself is almost as long as the abdominal cavity.

Gland—At the postero-ventral surface of the anterior chamber a glandular tissue is evident.

8. *Clarias batrachus* (Linnæus) (Figs. 8A and 8B):

Location—The gas bladder runs along almost the entire length of the abdominal cavity. It is retroperitoneal and ventral to the kidneys.

FIG. 8A. Side view of *Clarias batrachus* (Linnaeus) showing the gas bladder. B. C., abdominal cavity; G. B., gas bladder; and Kd., kidneys.

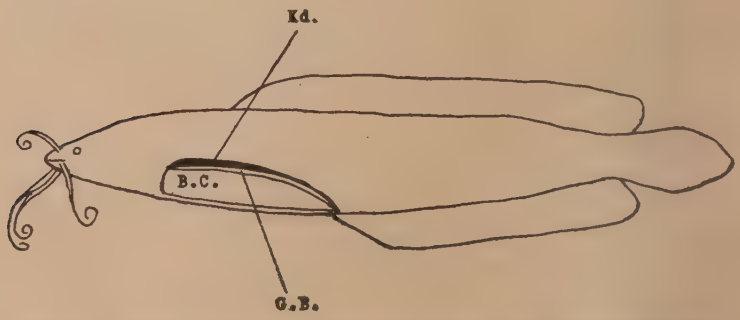

FIG. 8B. Ventral view of *C. batrachus* (Linn.) and its gas bladder.

Morphology—The gas bladder is physostomous and one-chambered. A pneumatic duct seems to be present in big specimens but in small specimens, about 12.5 cm. in total length, the duct could not be located. Ventrally the bladder appears triangular in shape, being broad anteriorly and tapering posteriorly. Viewed sidewise the bladder is rather flat. The wall

is thin and weak but strengthened and supported by the strong peritoneum ventrally. It adheres to the peritoneum so well that separation between the two is quite a task to undertake; persistence may only break the bladder wall. Dorsally no bladder wall is evident, an indication that the gas bladder is somewhat rudimentary.

Gland—No gland is evident.

9. *Tilapia mossambica* (Peters) (Figs. 9A and 9B):

Location—The gas bladder is conspicuously retroperitoneal and separated from the abdominal cavity by a black peritoneum.

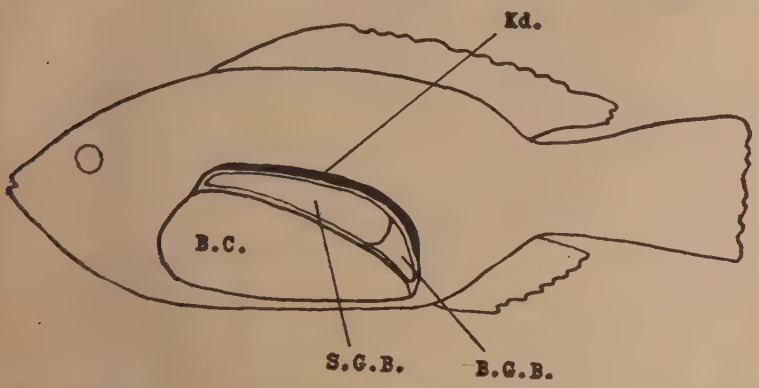

FIG. 9A. Side view of *Tilapia mossambica* Peters and its gas bladder. B. C., abdominal cavity; B. G. B., bigger gas bladder; Kd., kidneys and S. G. B., smaller gas bladder.

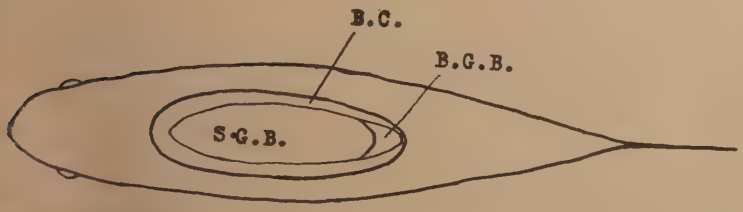

FIG. 9B. Ventral view of *T. mossambica* Peters and the gas bladder.

Morphology—The gas bladder is two-chambered but there is no interchamber duct between chambers. Instead a membrane divides the bladder in two near the posterior end. It therefore appears that a smaller bladder is enclosed in a bigger one. Although no orifice or interconnection between the two

chambers was noticed, the author believes that there must be some way by which gases can intermix between chambers.

The bladder is as long as the abdominal cavity looking from the outside. Inside it seems that a smaller bladder is present which extends posteriorly midway the posterior half of the bladder. The volume of the gas bladder is about half the abdominal cavity volume.

Gland—Glandular tissue is evident on the antero-ventral wall of the bladder.

10. *Glossogobius giurus* (Hamilton-Buchanan) (Figs. 10A and 10B):

Location—The bladder extends posteriorly to the anal region and anteriorly near the anterior portion of the stomach. It is dorsal to the other viscera and ventral to the kidneys, being retroperitoneal.

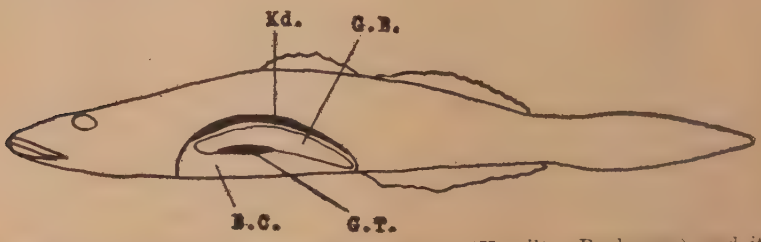

FIG. 10A. Side view of *Glossogobius giurus* (Hamilton-Buchanan) and its gas bladder. B.C., abdominal cavity; G.B., gas bladder; G.T., glandular tissue; and Kd., kidneys.

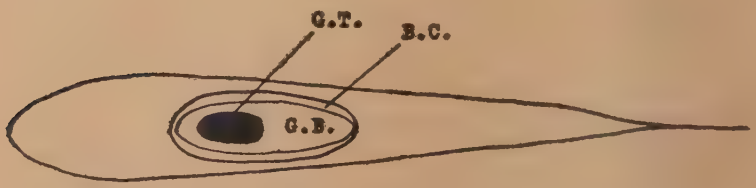

FIG. 10B. Ventral view of *G. giurus* (Hamilton-Buchanan) and its gas bladder.

Morphology—The gas bladder is single-chambered and physoclistous. The peritoneum adheres to the gas bladder wall quite well; mesenteries are hard to separate off without breaking the bladder wall. The bladder volume is less than the volume of the abdominal cavity.

Gland—The gas gland is very evident to the naked eye. It is a rounded glandular epithelium supplied by a blood vessel from the coeliaco-mesentric artery. This gland is found at the ventral region somewhat anterior to the middle part of the bladder. In addition, a dark, elongated, and small structure ventral to the gland and suspended by a mesentery seems to be related in function to the gas gland.

DISCUSSION

Among the fishes considered, gas bladders vary not only in size and shape but also in location. In *Clarias batrachus* we have a fish that has become specialized in some respects; this is shown by its quite rudimentary gas bladder. There are only three possibilities in which *Clarias* could have this type of gas bladder. Firstly, if the fish is a rapid vertical migrator, the presence of a well developed and functional gas bladder would hinder its movement (Jones, 1952); secondly, if it stays at the bottom most of the time; and thirdly, if it stays in shallow places only. The first two assumptions may be eliminated because *Clarias,* even if it stays at the bottom most of the time, is a partial air breather and must go to the surface to gulp air. The most plausible assumption would therefore be the last one. *Clarias* usually inhabits shallow places. Vertical migration done off and on is short, rapid, and abrupt and therefore would not require much the services of a gas bladder.

A very unique location of the bladder is found in the Order Labyrintnici which includes Families Ophicephalidæ and Anabantidæ. The peculiar location of the gas bladder in the tail region could be an indication of some type of specialization of the group. This, however, could not be correlated with the biology of the fishes concerned since on this aspect nothing much has been done or published. However, the location of the entire bladder in the tail region and the complete division of the bladder into right and left halves by an interbladder septum may indicate the more specialized characters of the group. Munro (1955) reported that the gas bladders of the Family Anabantidæ are divided posteriorly. The division is not only posterior in some cases. This is shown in *Trichogaster pectoralis* and the species may be considered the most specialized in the group. *Ophicephalus striatus* is the least specialized in the Order in that a portion of the bladder is located anterior to the tail region and the posterior end of the bladder does

not quite come to the caudal peduncle. Likewise the bladder is without the usual longitudinal interbladder septum. Next is *Anabas testudineus* because the anterior portion of the gas bladder is anterior to the tail region and the longitudinal division of the bladder is incomplete. In *Trichogaster trichopterus* a portion of the bladder is anterior to the tail region but the longitudinal division of the gas bladder is already complete. Based on the morphology and location of the gas bladders, the taxonomic positions given by Herre (1953) agree with the phylogeny of labyrinthic fishes.

There are no other gas bladders studied where location is as unique and as interesting. In all cases the gas bladder is retroperitoneal and ventral to the kidneys, except in cases when the gas bladder is in the tail region. Glandular epithelium is located at the antero-ventral portion of the bladder and this is possibly the gas gland. However, in *Hemiramphus* a glandular tissue is not visible to the naked eye which does not by any means indicate its absence in the bladder. The pneumatic duct present could have rendered the functions of the glands quite negligible and as such the gland is less developed than those in physoclistous fishes. In *Glossogobius giurus* the gas gland is well developed, appearing as a rounded rather thick structure. Histological studies on the gland may reveal interesting facts. The gross morphological studies did not reveal the presence of the oval gland but actually is present in the gas bladder. The oval gland is probably much smaller than the gas gland.

A gas bladder of two or three chambers is characteristic of cyprinid fishes (Order Cypriniformes) (Nelson, 1961). *Cyprinus carpio*, a cyprinid fish, has a two-chambered bladder with an interchamber duct. *Therapon plumbeus* similarly has a two-chambered bladder although taxonomically it does not belong to Cypriniformes. The gas bladder of *Tilapia mossambica*, on the other hand, is quite peculiar in being two-chambered but having no interchamber duct. There is no indication of an opening between the two chambers but it is assumed that gases can intermix between chambers.

Hubbs (1930) had used the number of chambers of the gas bladders as a taxonomic tool in catostomids (suckers). Using number of chambers of the bladder as a criterion, Robins and Raney (1956) had determined the proper placing and synonymy of various species of catostomids (taken from Nelson, 1961). Considering the fishes studied under Order Labyrinthici, the

morphology of the gas bladder can serve as taxonomic criterion for the group. The following is an illustrative key.

Key to the fishes of Order Labyrinthici [1]

1a. Bladder elongated; tube extending from over abdominal cavity to tail region but stopping short of the caudal peduncle; interbladder septum in the gas bladder ..... Family Ophicephalidæ;

1b. Bladder either confined entirely in tail region or not quite; bladder extended to caudal peduncle; interbladder septum present, longitudinal division of bladder incomplete (not extending to posterior portion of bladder) or complete (extending to posterior portion of bladder) ..... Family Anabantidæ;

2a. Bladder confined in tail region except for anterior portion; longitudinal division of bladder incomplete ..... Genus *Anabas;*

2b. Bladder either entirely or not entirely confined in tail region; longitudinal division of bladder complete ..... Genus *Trichogaster;*

3a. Bladder not entirely in tail region ..... *T. trichopterus;* and

3b. Bladder completely confined in tail region ..... *T. pectoralis.*

This key is tentative in character pending further studies of other members of the Order Labyrinthici. From the above indications it appears that using morphological differences of the gas bladders for taxonomic purposes is quite sound and valid.

SUMMARY

1. Ten species of fishes from Laguna de Bay belonging to eight families are used in this paper. Location, morphology, and the presence of glandular tissue are the aspects noted of their gas bladders.

2. An attempt to correlate the phylogeny, or specialization, of fishes belonging to Order Labyrinthici is made. The location of the bladder in the tail region as well as the complete division of the bladder by an interbladder septum are considered the advanced characteristics of fishes belonging to this group.

3. The presence of rudimentary gas bladder in *Clarias batrachus* is strongly correlated to its habit and habitat.

4. Gross morphological examination of the glands did not reveal the oval glands. Glandular development is less in physostomous fishes (*Hemiramphus georgii*) than in physoclistous fishes.

5. A key to the identification of two families (Ophicephalidæ and Anabantidæ) of the Order Labyrinthici is presented based on the morphology of the gas bladders.

[1] Only species of fish studied are included in the key.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. *Cyprinus carpio* Linn. with its gas bladder shown at side view.
2A. The side view of *Hemiramphus georgii* Cuv. & Val. and its bladder.
B. Ventral view of *H. georgii* Cuv. & Val. showing the gas bladder.
3A. Side view of *Ophicephalus striatus* Bloch showing location and shape of the gas bladder.
B. Ventral view of *O. Striatus* Bloch and its gas bladder.
4A. Lateral view of *Anabas testudineus* Bloch with the gas bladder shown.
B. Ventral view of *A. testudineus* Bloch showing the gas bladder.
5A. Side view of *Trichogaster trichopterus* Pallas showing the gas bladder.
B. Ventral view of *T. trichopterus* Pallas and its gas bladder.
6A. Side view of *Trichogaster pectoralis* Regan showing its gas bladder.
B. Ventral view of *T. pectoralis* Regan with its gas bladder shown.
7A. Lateral view of *Therapon plumbeus* Kner showing the shape and position of the gas bladder.
B. Ventral view of the gas bladder of *T. plumbeus* Kner.
8A. Side view of *Clarias batrachus* Linnaeus showing the gas bladder.
B. Ventral view of *C. batrachus* Linn. and its gas bladder.
9A. Side view of *Tilapia mossambica* Peters and its gas bladder.
B. Ventral view of *T. mossambica* Peters and the gas bladder.
10A. Side view of *Glossogobius giurus* Hamilton-Buchanan and its gas bladder.
B. Ventral view of *G. giurus* Hamilton-Buchanan and its gas bladder.

INORGANIC FERTILIZERS FOR PONDFISH CULTURE[1]

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SEVEN TEXT FIGURES

This paper endeavors to review the fishpond fertilization practices in countries in the Indo-Pacific region, and to discuss some basic information on the use of inorganic fertilizers obtained from experiments done by the writer in Auburn, Alabama, U.S.A.

Fishpond Fertilization in the Indo-Pacific Region

The efforts directed toward increasing fish production in fishponds in the Indo-Pacific area have received considerable attention. The addition of fertilizing substances to ponds in order to attain increased production has been extensively practised. Unfortunately, most of the trials have been confined largely to the random application of organic materials that are cheap and easily available in the localities of application. Whatever abounds locally would be used singly and in rare instances with inorganic nutrients. It is often difficult to establish whether these organic matters are fertilizers for the ponds or direct feeds for the fish stock. The kind of fertilizer and the amount used as well as methods of application vary with indigenous experiences and availability of fertilizing products. Only recently have experiments on the use of inorganic fertilizers been undertaken.

Japan.—To derive maximum production from fishponds, intensive fish culture techniques including the use of fertilizers and artificial feeds are utilized in Japan. Frequent and heavy feeding of the fish stock is done and undoubtedly the feed used served as direct fish food and fertilizer as well. Some of the substances commonly used include silkworm pupae, cereal by-products (rice bran and meddlings and barley),

[1] Presented at the TENTH PACIFIC SCIENCE CONGRESS of the Pacific Science Association, held at the University of Hawaii, Honolulu, Hawaii, U.S.A., 21 August to 6 September 1961.

male chicks from poultry farms, cheap marine fish (sardines) and slaughterhouse products (horse and pig livers, etc.) prepared for pond application.

Inorganic fertilization of fishponds was considered in Japan previously as a minor management practice. In the hope of triggering off the growth of the desirable flora, the phytoplankton, one to two applications of ammonium sulfate and superphosphate used to be routinely done. In some instances, pond fertilization with inorganic substances met with disfavor due to their added fertilizing effect on obnoxious weeds. This could have been due to minimal application of the mineral fertilizer. In recent years, studies have been conducted on the use of this type of fertilizer in heavier dosage and more frequent application than previously practised. Seven applications instead of one or two per year have been tried with good results. Maximum success has been shown with combined intensive feeding and inorganic fertilizer application.

Taiwan—Intensive methods of fish cultivation are practised in the fishponds of Taiwan. Heavy feeding with various organic materials indistinguishable from fertilization per se, has long been a standing practice. The more common substances used include: rice and wheat bran, night soil, tea seed, peanut and soybean cake, *Leucaena* seed meal and various animal manures. For a long time a pattern of fertilization characterized by four applications of these organic fertilizers during the crop season was followed. Then there grew a great demand for these fertilizing materials, giving rise to unprecedented costs.

From 1953 to 1956 a series of experiments was undertaken to determine the effectiveness of inorganic fertilizers which heretofore had not been generally utilized in fishponds. These studies included comparison of the efficiency and economy of using organic and inorganic materials applied singly or combined. The following results were established:

1. Inorganic fertilizers of 8–9–2 or 8–4–2 (N–P–K) at the rate of 300 to 500 kilograms per hectare per year can be used successfully in Taiwan ponds used for raising milkfish (*Chanos chanos*);
2. Inorganic fertilizers were found more effective in clear pond water with salinity above 1.5 per cent and sufficient sunlight reaching the pond bottom;

3. The average production of ponds treated with complete inorganic fertilizer was equal to that produced by treatment with rice bran in amounts double or with night soil 30 times the mineral fertilizer used;
4. Based on current prices in Taiwan at the time the studies were being conducted, the expenses incurred with the use of organic materials exceeded that of the chemical fertilizers; and
5. Compared with ponds receiving either chemical or organic fertilizers, those receiving combined chemical and organic fertilizers, yielded highest increase in production.

Southern China and Hongkong.—The use of organic materials both as feeds and fertilizing substances in ponds is also an age-long management technique in Southern China and Hongkong. The materials used include silkworm pupae, cut land grass, soybean meal, goatweed and other strong odored weeds (mint family), pig, sheep, buffalo and cattle manure, night soil, tea seed, poultry droppings, aquatic plants, rice bran and broken rice, and peanut cake. It is not unusual for one to see latrines, and pig and duck pens built over the ponds.

There seems to be no standard method of fertilizer application in this area but different local practices have been developed in the different fish producing communities. Different organic fertilizers such as cow dung, green manure, hog manure, and others are often rotated during the growing season. Likewise, fish and plant crops are rotated in the same field. With the continued use of organic fertilizers the pond bottom gradually becomes elevated necessitating periodic draining of the pond water and drying and scraping of the bottom soil.

It has not been noted whether or not inorganic fertilizers have been used in Southern China and Hongkong.

Malaya and Singapore.—All cheap and easily available organic materials are used in ponds to serve the dual purpose of feeding and fertilizing. There are no records noted showing whether or not inorganic fertilizers have been used. However, with the establishment of the Fish Culture Research Institute at Batu Berendam, Malacca, Malaya, experiments on mineral fertilization of ponds are being undertaken. Recent findings of that Institute on N–P_2O_5–K_2O used separately and in various combinations show that 40 pounds of P_2O_5 per acre per year is the optimum fertilization for ponds in that region. This rate produced a poundage even higher than that produced

by ponds fertilized with 6–3/4 tons of cow dung, an indication that inorganic fertilizers can be as cheap if not cheaper than organic manures for fishpond fertilization.

"Mixed farming" or the integration of animal husbandry, crop raising and fish culture in order to obtain the maximum utility for a given piece of farmland, is a well-developed practice in Malaya. The unique feature of this scheme is the attempt to circulate within the system the nutrients that have been made available to it from outside and conserving these nutrients in order to reduce to the minimum the requisition of external materials. Thus, the animal wastes fertilize the water to produce the maximum growth of microscopic plants as well as higher aquatic plants. These are in turn fed on by the fish. Part of the luxuriant growth of higher aquatic plants and excess stock of the rapidly multiplying species of fish are gathered and used to augment the feed used in the animal husbandry unit. In order to maintain their original depth, ponds are periodically drained, dried, and their bottoms scraped. The scrapings have been found good vegetable garden and orchard fertilizers.

India.—The method of fertilization characterized by heavy use of organic substances and manures as direct feeds and pond fertilizing materials practised in the Indo-Pacific region holds true with India. The materials commonly used include cow dung, stable refuse, poultry manure, oil cake and cut grass bundles.

With the growth of cities and unprecedented increase in population, the efficient disposal of refuse and sewage has become a big problem. India has demonstrated, particularly in the Bidyadhari Spill area in Calcutta, that fish culture in sewage-irrigated areas can provide a cheap means of sewage purification. From the stand-point of sanitation it has been observed that fish, fortunately, can not survive normally at points in the sewage line where the oxygen content is too low and where pathogens are to heavy to cause danger to public health. On the other hand, where the water has become clear and/or well diluted the enriched water favors a very rapid growth of the desirable species of fish to marketable size in as brief a period of 6 to 8 months.

Indonesia.—Like all the other countries of the Indo-Pacific region, Indonesia utilizes organic materials and manures for

the artificial enrichment of her fishponds. Pig, duck and other animal manures are used. Vegetables found in quantities are used as green manuring materials. Experiments on the use of marygold plant, *Tithonia diversifolia,* for green manuring resulted in increased production of common carp (*Cyprinus carpio*) and tilapia (*Tilapia mossambica*) in ponds.

The use of inorganic fertilizers in this country is in the experimental stage. Its bright prospects seem to be indicated by the surprisingly high production derived from ponds in volcanic areas, the water of which is heavily laden with mineral nutrients.

Because of management practice in this area, brackish water ponds for milkfish are incidentally fertilized. Periodic replenishing of the pond water with new tidal water brings in nutrients with the water supply. The draining and drying of the pond bottom after each crop period is invariably followed by heavy growth of blue-green algae in the ponds. It has been postulated that nitrogen fixation may be taking place with the growth of this type of algae.

The use of sewage water from population centers for fish production purposes has proven to be successful in the cities of Jogjakarta and Bandung. Here fresh sewage are first treated by technical means in septic tanks and later allowed to flow and mix with irrigation water for ponds where fish is raised or to ricefields where, besides rice, fish is raised. High fish production for common carp, tilapia and milkfish has been derived from these sewaged-fed areas.

Philippines.—Pondfish culture in the Philippines is predominantly confined to brackish water ponds for milkfish; freshwater fishponds are still few and limited in extent. The peculiar management practice developed in this country's brackish water fishponds seems to provide for some degree of self-fertilization. This practice appears identical with those observed in Indonesian milkfish ponds. During the crop period, the regular replenishment of the pond water during the spring tides allows entrance of nutrients with the incoming water. After each cropping, the ponds are drained and exposed to sunlight. Usually a heavy growth of benthic algae predominantly of blue-green group develops immediately following this period. That fixation of nitrogen possibly takes place at the pond bottom at this time has been advanced by some workers in this field.

Artificial feeding to a limited extent is also practised in Philippine milkfish ponds. Feed used as direct fish food undoubtedly serves also as fertilizer. Rice bran is the principal item used especially in milkfish pond nurseries. Corn bran, bakery wastes and cereal by-products are also used. Animal manures especially poultry droppings are generally applied when available as fertilizers. These have been observed, fed on directly by the fish.

The use of inorganic fertilizers is under investigation with some indications of success. Experiments in the use of 8–18–4 (N–P–K) in milkfish pond nurseries resulted in better growth of the fish food, greater stocking capacity of ponds (from 30 to 50 fry per square meter) and faster rate of growth of the milkfish fingerlings. In milkfish rearing ponds complete fertilizer formulation 12–12–12 (N–P–K) was found to effect better growth on the algal food of the milkfish. In repeated experimental trials in one of the Philippine Bureau of Fisheries Fish Farm Stations for milkfish, repeated use of 16–20–0 (N–P–K) resulted in an average production of 1.3 tons of fish per hectare per year. This is almost four times greater than the present average production from unfertilized ponds in this country.

In spite of the demonstrated successes of these experiments general adoption of fertilization of ponds with inorganic substances has not come into being. The dearth of supply and the prohibitive prices demanded for inorganic fertilizers draw setbacks for their general use.

Results of an Experiment on Inorganic Fertilizers Done in Auburn, Alabama, U. S. A.

As a part of a continuing study on pond fertilization at the Farm Ponds Project, Agricultural Experiment Station of the Auburn University, Auburn, Alabama, the writer carried on a year-round experiment during the 1959 crop period. The study was designed to test the effect of no fertilization and non-nitrogenous fertilization in ponds that had received continued complete fertilizers during the preceding 15-year period. Two species of fish, common carp and goldfish (*Carassius auratus*), were used separately in three fertilizer treatments, namely, 0–0–0, 0–8–2, and 8–8–2 pounds of N–P_2O_5–K_2O per acre per application.

Results on chemistry of pond water.—The concentration of total nitrogen dissolved and in suspension in the water was related to the fertilization the ponds received; it was highest in the 8–8–2, followed next in the 0–8–2 and lowest in the 0–0–0 ponds (Table 1). These differences in levels in the three treatments were significant. The amount of total nitrogen in each of the unfertilized ponds remained at more or less the same level throughout the experimental period. The 0–8–2 ponds gradually increased in their total nitrogen content toward the

TABLE 1.—*Parts Per Million Total Nitrogen At Approximately Monthly Intervals In Ponds Receiving Different Fertilizer Treatments.*

Month	Carp ponds			Goldfish ponds			Period totals
	0–0–0	0–8–2	8–8–2	0–0–0	0–8–2	8–8–2	
1. April	0.97	0.68	1.07	0.94	0.79	1.61	13.40
	1.38	0.96	1.36	1.69	0.93	1.02	
2. May	1.44	1.43	1.12	0.87	1.43	1.56	14.30
	0.72	1.24	1.27	0.72	1.38	1.12	
3. June	0.74	1.08	2.18	0.49	0.61	0.93	12.07
	0.81	0.84	1.27	1.13	1.09	0.90	
4. July	0.91	0.94	1.08	1.11	0.78	1.24	12.21
	0.70	1.44	1.49	0.70	0.58	1.24	
5. August	1.11	1.33	1.39	1.18	1.51	1.22	13.90
	0.56	0.96	1.23	0.92	1.35	1.14	
6. September	0.77	1.01	1.54	1.07	1.23	1.58	14.08
	1.02	1.51	1.20	0.77	0.88	1.50	
7. October	0.86	0.98	1.47	0.91	0.80	2.16	14.84
	1.18	1.44	1.64	0.72	1.42	1.26	
Treatment totals	13.17	15.84	19.31	13.22	14.78	18.48	
Treatment totals (both fish)				26.39	30.62	37.79	

end, and that in the 8–8–2 the nitrogen content increased at an even higher rate than in the 0–8–2 (Fig. 1).

The inorganic nitrogen component (ammonia plus nitrate) in all the ponds started at a relatively high level and gradually decreased toward the end of the experiment. Ammonia, the more abundant fraction, declined rapidly during the period (Table 2 and Figures 2a and 2b). Nitrate was in minute quantities, but gradually increased during the experimental period (Table 3 and Figures 3a and 3b). Close relationship between the decline of inorganic nitrogen on the one hand and the increase of plankton on the other was observed.

Ammonia and nitrate in ponds receiving similar fertilizer treatments differed significantly in levels in the carp and goldfish ponds. Ammonia concentration was lower in the carp ponds than in the goldfish ponds; as carp stir the pond bottom

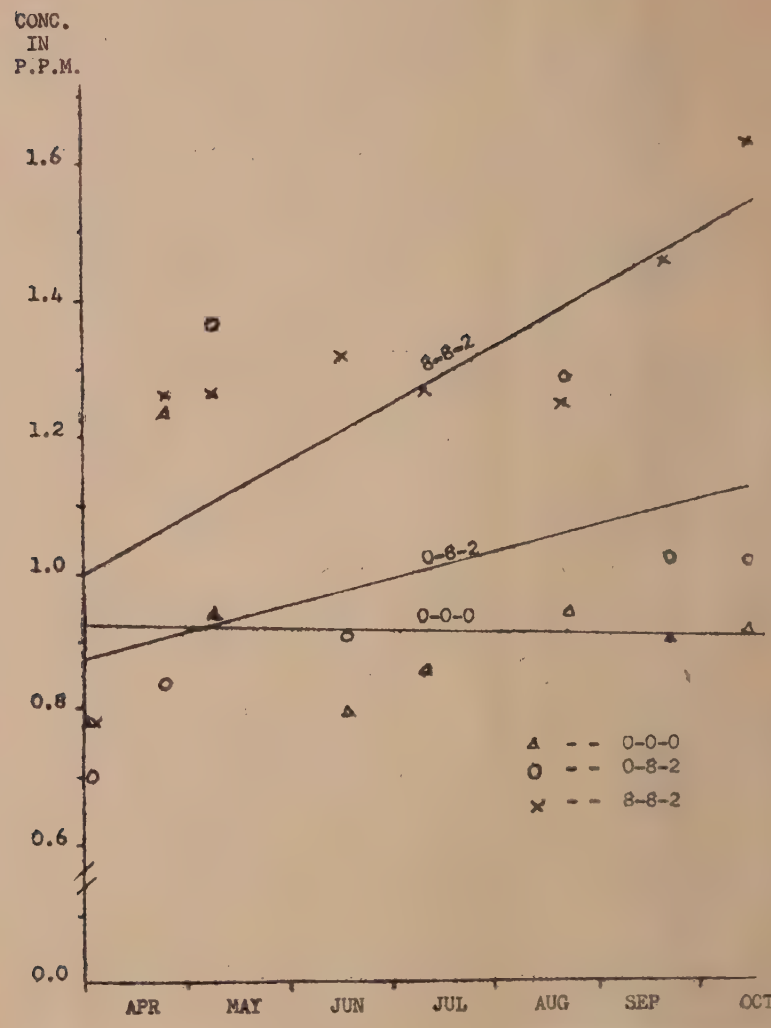

FIG. 1. REGRESSION LINES OF TOTAL NITROGEN CONTENTS OF POND WATERS RECEIVING DIFFERENT FERTILIZER TREATMENTS

and muddy the water, more rapid absorption of ammonia on clay colloids probably took place (Table 2 and Figures 2a and 2b). The nitrate concentrations were higher in the carp

TABLE 2.—*Parts Per Million Ammonia Nitrogen at Approximately Monthly Intervals In Ponds Receiving Different Fertilizer Treatments.*

Month	Carp ponds			Goldfish ponds			Period totals
	0–0–0	0–8–2	8–8–2	0–0–0	0–8–2	8–8–2	
1. April	0.37	0.29	0.13	0.35	0.29	0.30	4.20
	0.38	0.35	0.31	0.64	0.36	0.43	
2. May	0.38	0.37	0.34	0.53	0.30	0.41	4.30
	0.22	0.13	0.16	0.66	0.20	0.60	
3. June	0.20	0.29	0.34	0.23	0.26	0.41	4.28
	0.43	0.26	0.45	0.52	0.37	0.52	
4. July	0.18	0.26	0.29	0.18	0.14	0.24	2.93
	0.20	0.28	0.23	0.25	0.34	0.34	
5. August	0.13	0.13	0.20	0.21	0.13	0.21	2.49
	0.15	0.31	0.30	0.19	0.29	0.24	
6. September	0.04	0.06	0.13	0.14	0.08	0.08	1.19
	0.13	0.16	0.12	0.04	0.06	0.15	
7. October	0.08	0.04	0.32	0.12	0.04	0.24	1.81
	0.09	0.14	0.12	0.06	0.18	0.38	
Treatment totals	2.98	3.07	3.44	4.12	3.04	4.55	
Treatment totals (both fish)				7.10	6.11	7.99	

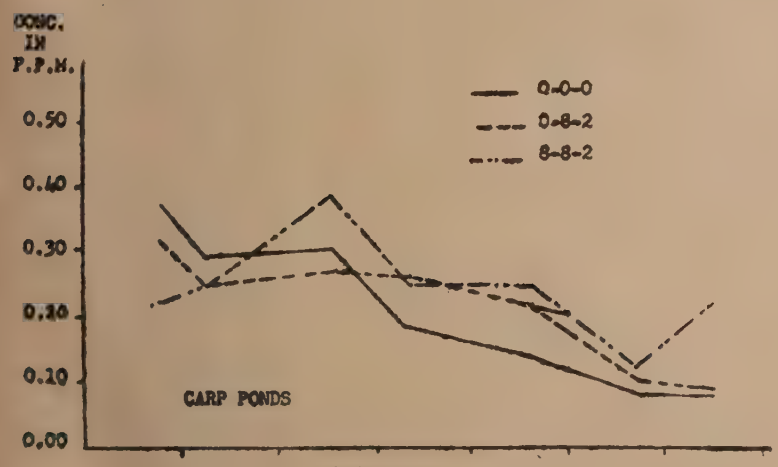

FIGURE 2a

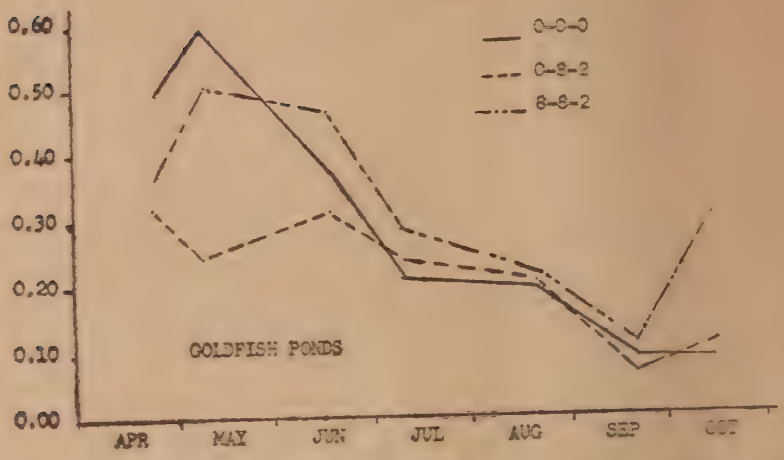

FIGURE 2b

AMMONIA CONCENTRATIONS IN CARP AND GOLDFISH PONDS RECEIVING DIFFERENT FERTILIZER TREATMENTS.

than in the goldfish ponds (Table 3 and Figures 3a and 3b). This indicated less effective use of this nutrient for plankton production in the carp ponds, probably as a result of the muddy water.

TABLE 8.—*Parts Per Million Nitrate Nitrogen At Approximately Monthly Intervals In Ponds Receiving Different Fertilizer Treatments.*

Month	Carp ponds			Goldfish ponds			[illegible] ponds
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
1. April	0.07	0.06	0.07	0.03	0.06	0.05	[illegible]
	0.04	0.05	0.06	0.05	0.05	0.04	
2. May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	0.06	0.07	0.06	0.05	0.11	0.08	
3. June	0.07	0.14	0.15	0.05	0.07	0.10	1.08
	0.06	0.10	0.10	0.06	0.10	0.08	
4. July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.02
	0.14	0.13	0.14	0.06	0.08	0.09	
5. August	0.08	0.10	0.10	0.04	0.06	0.09	1.27
	0.11	0.12	0.17	0.13	0.11	0.07	
6. September	0.09	0.10	0.06	0.07	0.13	0.11	[illegible]
	0.09	0.11	0.23	0.07	0.10	0.11	
7. October	0.12	0.20	0.10	0.09	0.12	0.11	1.42
	0.10	0.12	0.24	0.06	0.06	0.20	
	0.10	0.18	0.09	0.06	0.12	0.08	
Treatment totals	1.19	1.61	1.64	0.87	1.26	1.32	
Treatment totals (both fish)				2.06	2.87	2.96	

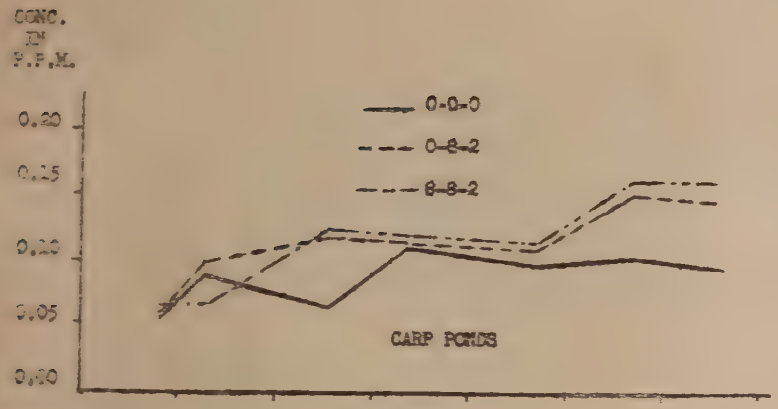

FIGURE 3a

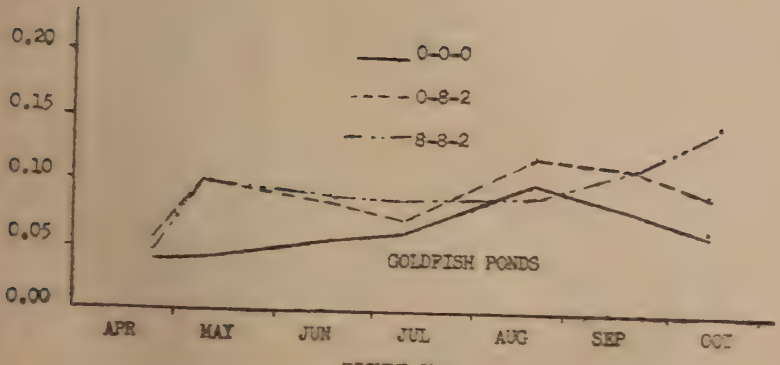

FIGURE 3b

NITRATE CONCENTRATIONS IN CARP AND GOLDFISH PONDS RECEIVING DIFFERENT FERTILIZER TREATMENTS.

641-16——3

The amounts of organic nitrogen in the fertilized 8–8–2 and 0–8–2 ponds were significantly higher than in the unfertilized ponds (Table 4 and Figure 4). In the completely fertilized ponds (8–8–2) the concentration gradually increased and was significantly higher than in the phosphate-potash fertilized ponds (0–8–2). The organic nitrogen content of the 0–8–2 ponds fluctuated drastically during the experimental period with only a slight build-up toward the end of the experiment; in the 0–0–0 ponds it remained low, fluctuated and did not appear to have increased in level at the termination of the experiment (Figure 4).

TABLE 4.—*Parts Per Million Organic Nitrogen At Approximately Monthly Intervals in Ponds Receiving Different Fertilizer Treatments.*

Month	Carp ponds			Goldfish ponds			Period totals
	0–0–0	0–8–2	8–8–2	0–0–0	0–8–2	8–8–2	
1. April	0.53	0.33	0.87	0.56	0.44	1.26	8.57
	0.96	0.56	0.99	1.00	0.52	0.55	
2. May	1 00	0.93	0.71	0.31	1.04	1.03	9.07
	0.44	1.04	1.05	0.01	1.07	0.44	
3. June	0.47	0.65	1.69	0.21	0.28	0.42	6.71
	0.32	0.48	0.72	0.55	0.62	0.30	
4. July	0.59	0.54	0.64	0.85	0.56	0.91	8.13
	0.42	1.06	1.16	0.40	0.18	0.82	
5. August	0.87	1.08	1.02	0.94	1.27	0.94	10.24
	0.32	0.55	0.87	0.66	0.93	0.79	
6. September	0.64	0.84	1.18	0.86	1.05	1.39	11.44
	0.77	1.15	0.98	0.64	0.70	1.24	
7. October	0.68	0.82	0.91	0.73	0.70	1.72	11.62
	0.99	1.12	1.43	0.60	1.12	0.80	
Treatment totals	9.00	11.15	14.22	8.32	10.48	12.61	
Treatment totals (both fish)				17.32	21.63	26.83	

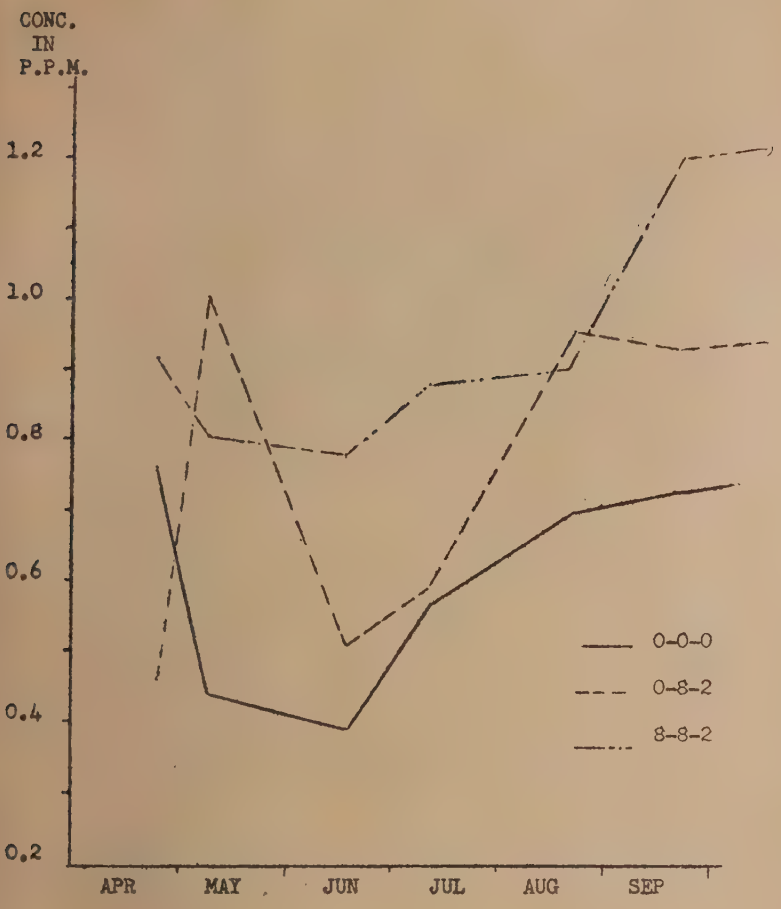

FIG. 4. ORGANIC NITROGEN CONCENTRATIONS IN PONDS RECEIVING DIFFERENT FERTILIZER TREATMENTS.

The concentration of dissolved inorganic phosphorus in the pond waters was related to the fertilizer treatment; it was significantly higher in the 0–8–2 and 8–8–2 than in the unfertilized ponds (Table 5 and Figures 5a and 5b). The

TABLE 5.—*Parts Per Million Dissolved Inorganic Phosphorus At Approximately Monthly Intervals In Ponds Receiving Different Fertilizer Treatments*

Month	Carp ponds			Goldfish ponds			Period totals
	0-0-0	0-8-2	8-8-2	0-0-0	0-8-2	8-8-2	
1. April	0.01	0.11	0.03	0.02	0.05	0.11	0.47
	0.02	0.03	0.04	0.01	0.02	0.02	
2. May	0.01	0.09	0.04	0.01	0.07	0.08	0.42
	0.02	0.02	0.03	0.02	0.01	0.02	
3. June	0.08	0.08	0.12	0.05	0.05	0.07	0.88
	0.04	0.09	0.09	0.06	0.05	0.10	
4. July	0.02	0.02	0.02	0.02	0.02	0.04	0.33
	0.02	0.05	0.04	0.02	0.02	0.04	
5. August	0.02	0.02	0.02	0.03	0.02	0.03	0.28
	0.01	0.02	0.02	0.02	0.04	0.03	
6. September	0.02	0.06	0.05	0.05	0.04	0.08	0.78
	0.06	0.11	0.12	0.04	0.07	0.08	
7. October	0.04	0.07	0.10	0.05	0.07	0.10	0.85
	0.05	0.10	0.06	0.05	0.08	0.08	
Treatment totals	0.42	0.87	0.78	0.45	0.61	0.88	
Treatment totals (both fish)				0.87	1.48	1.56	

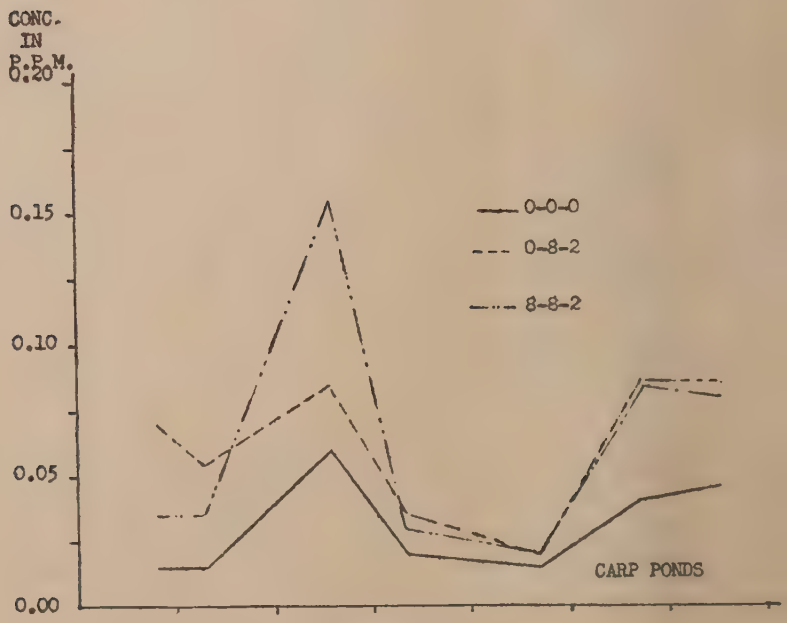

FIGURE 5a

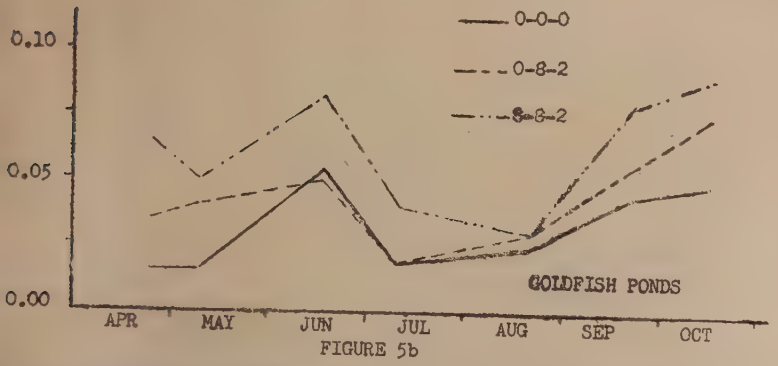

FIGURE 5b

PHOSPHORUS CONCENTRATIONS IN CARP AND GOLDFISH PONDS RECEIVING DIFFERENT FERTILIZER TREATMENTS

disappearance of inorganic phosphorus from the pond water after its application was extremely rapid; it was being lost at the rate of 12.7 per cent per day in the 0–8–2 and 14.3 per cent per day in the 8–8–2 ponds (Figure 6). The phosphorus content of the pond waters underwent unexplained cyclic changes during the experimental period (Figures 5a and 5b).

Plankton and bottom fauna.—Carp utilized bottom fauna (mainly aquatic insects) more completely than goldfish (Table 7). This was because carp feed heavily on bottom organisms while goldfish feed largely on plankton from the surface to the pond bottom. The amount of plankton and aquatic insects produced in the fertilized 8–8–2 and 0–8–2 ponds was significantly higher than in the unfertilized ponds (Tables 6 and 8 and Figure 7). A trend was indicated in the averages per sampling period that the 8–8–2 ponds had higher amounts of plankton and aquatic insects than the 0–8–2 ponds, but the difference was not statistically significant (Tables 6 and 8).

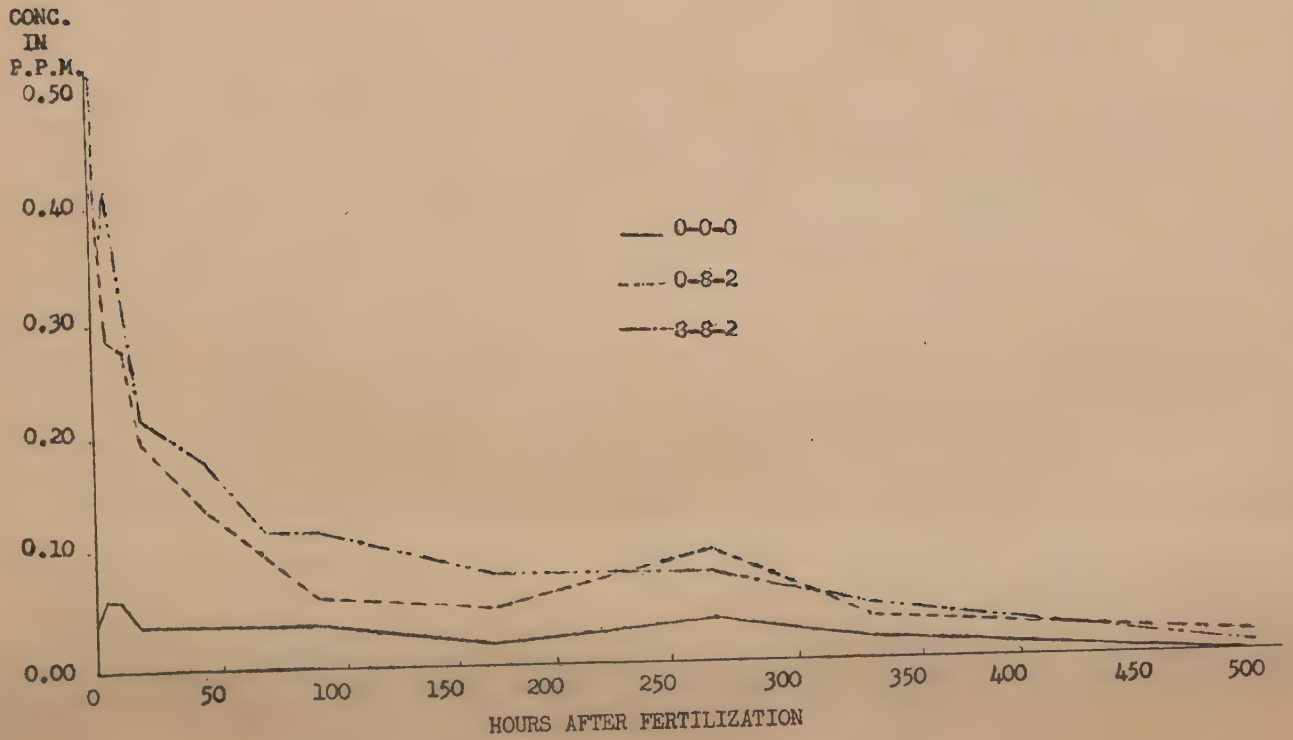
CONC. IN P.P.M.
0.50
0.40
0.30
0.20
0.10
0.00
0
50
100
150
200
250
300
350
400
450
500
0-0-0
0-8-2
8-8-2
HOURS AFTER FERTILIZATION

FIGURE 6

TABLE 6.—*Milligrams per liter plankton at approximately monthly intervals in ponds receiving different fertilizer treatments.*

Month	Carp ponds			Goldfish ponds			Period totals
	0–0–0	0–8–2	8–8–2	0–0–0	0–8–2	8–8–2	
1. April	3.0	2.9	8.1	5.9	7.6	19.0	73.9
	2.6	3.9	8.8	4.1	3.5	4.5	
2. May	3.6	6.9	4.0	6.1	7.7	12.9	84.3
	2.5	9.2	8.1	4.3	10.0	9.0	
3. June	7.0	10.5	9.7	8.4	6.4	8.7	98.7
	6.7	10.7	9.1	5.0	5.6	10.9	
4. July	10.2	6.8	11.7	5.8	13.4	8.8	109.0
	7.5	15.0	11.2	5.4	6.0	7.2	
5. August	7.1	11.1	7.1	7.6	8.1	9.9	108.4
	6.4	7.8	10.3	11.4	11.1	10.5	
6. September	5.6	10.0	11.6	8.6	8.3	10.7	118.4
	10.3	20.4	8.6	7.2	7.8	9.3	
7. October	6.0	8.6	16.3	7.0	7.0	10.9	120.1
	11.2	20.8	9.2	6.1	8.8	8.2	
Treatment totals	89.7	144.6	133.8	92.7	111.3	140.5	
Treatment totals both fish				182.4	255.9	274.3	

TABLE 7.—*Ekman dredge sampling of bottom organisms (in milligrams dry weight per square foot of pond bottom)*[1]

Period	Carp ponds			Goldfish ponds			Period totals
	0–0–0	0–8–2	8–8–2	0–0–0	0–8–2	8–8–2	
1. June	2.24	6.11	3.97	4.16	12.95	0.00	40.13
	0.00	0.32	1.81	1.28	2.90	4.39	
2. September	0.88	0.84	1.28	2.63	2.20	3.15	34.56
	0.11	2.56	2.13	8.33	0.53	9.92	
3. October	0.96	2.91	0.21	1.16	3.73	1.65	49.44
	0.96	3.84	5.32	13.39	3.91	11.40	
Treatment totals	5.15	16.58	14.72	30.95	26.22	30.51	
Totals in carp and goldfish ponds		36.45			87.68		

[1] Values are given for each of two ponds for each treatment.

TABLE 8.—*Relative volumes of aquatic insects from ponds receiving different fertilizer treatments collected from masonite plate collectors (milliliters per square foot of surface)*[2]

Period	Carp ponds			Goldfish ponds			Period totals
	0-0-0	0-8-2	8-8-2	0-0-0	0-8-2	8-8-2	
1. June	0.5	4.0	10.2	0.1	5.8	11.5	52·9
	0.0	0.5	8.5	0.2	9.5	2.1	
2. July	5.5	6.5	8.0	8.0	2.9	7.5	57.3
	0.0	6.0	2.5	0.9	1.5	8.0	
3. August	2.5	4.0	14.0	10.5	3.2	3.9	54.4
	0.2	2.2	3.7	0.4	4.8	5.0	
4. September	2.5	4.4	3.6	2.4	4.5	7.6	49.3
	2.0	3.4	2.9	0.8	8.0	7.2	
5. October							
Treatment totals	13.2	31.0	53.4	23.3	40.2	52.8	
Totals in carp and goldfish ponds		97.6			116.3		

[2] Values are given for each of two ponds for each treatment.

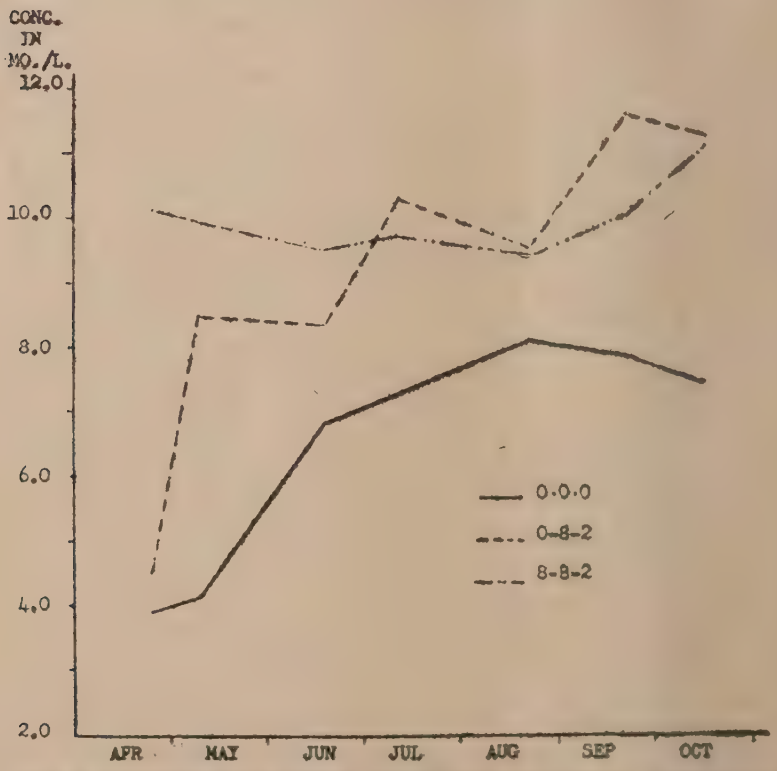

FIG. 7. PLANKTON IN PONDS RECEIVING DIFFERENT FERTILIZER TREATMENTS.

Fish production.—The production of fish both carp and goldfish was highest where complete fertilization was continued, followed next by phosphate-potash fertilization and lowest with no fertilization as indicated in the following table:

Fertilizer treatment	Average total production of Ponds in pounds per Acre	
	Carp	Goldfish
0–0–0	275.2	422.6
0–8–2	312.4	616.2
8–8–2	348.8	700.6

The increases in goldfish production resulting from 8–8–2 and 0–8–2 fertilization were significant; the increases in carp production were not significant although the averages in the 8–8–2 and 0–8–2 were consistently higher than in the unfertilized ponds. It may be speculated that longer period of the experiment might raise the difference to a level of significance.

General comments.—Some residual effect of the continued yearly application of complete fertilizers in the ponds during the fifteen years previous was noted. The unfertilized ponds in this experiment were calculated to be producing 3.7 times more carp and 1.7 more goldfish than in the original unfertilized state.

The fish, aquatic insects and plankton production of the ponds receiving different fertilizer treatments indicated that higher production resulted when fertilizers were applied. The chemical data tended to show that indigenous pond sources and/or fixation (in the case of nitrogen) can not fully be relied upon to supply the needs of continued and intensified biological production; for better results, the application of a suitable formulation of complete fertilizers is imperative.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Regression lines of total nitrogen contents of pond waters receiving different fertilizer treatments.

2A. & B. Ammonia concentrations in carp and goldfish ponds receiving different fertilizer treatments.

3A. & B. Nitrate concentrations in carp and goldfish ponds receiving different fertilizer treatments.

4. Organic nitrogen concentrations in ponds receiving different fertilizer treatments.

5A. & B. Phosphorous concentrations in carp and goldfish ponds receiving different fertilizer treatments.

6. Phosphorous in pond waters at selected intervals after the application of fertilizers.

7. Plankton in ponds receiving different fertilizer treatments.

PRELIMINARY OBSERVATIONS ON THE OTTER TRAWL FISHERY OF MANILA BAY

By Inocencio A. Ronquillo, Priscilla Caces-Borja, and Antonio Mines
Of the Philippine Fisheries Commission

ONE TEXT FIGURE

ABSTRACT

Early in 1957, the Section of Hydrology and Fisheries Biology of the Philippine Bureau of Fisheries started a program for reevaluating the trawl fishery in Manila Bay to compare the results obtained from previous studies by Warfel and Manacop (1950). This paper is a preliminary report covering the first three-year period from 1957 through 1959 based primarily on the data gathered by the technical staff of the above-mentioned Section who joined the fishing trips of commercial vessels fortnightly, each trip lasting from 3 to 5 days.

The otter trawlers were primarily of the design and type previously mentiond by Warfel and Manacop (1950). It was found that there has been a slight increase in the number of fishing vessels operating in Manila Bay during the period under review with a resulting decrease in the total average catch. A classification of fish caught, based primarily on the commercial method, was used in this study, classifying the catches into hoya, shrimp, squid, slipmouth, lizard fish, and miscellaneous group. It has been shown that there has been a decrease in the catch per hour drag from 1957 to 1959. There has been noted also a direct correlation between the boats operating in the Bay and the seasons of the year.

It is believed that the Manila Bay trawl fishery has reached its maximum development and this led to a change of gear for catching pelagic fish outside Manila Bay, namely, the *basnigan* and the introduction of twin engines into larger trawlers to enable them to catch more pelagic species in the Bay. Analyses of the catch of four fishing vessels representing typical size groups support the foregoing conclusion.

INTRODUCTION

The major net fisheries of Manila Bay are of three types, namely: the otter trawl, the baby trawl, and the *basnigan* (bagnet) fisheries.

Early in 1957, the Section of Hydrology and Fisheries Biology, Division of Fisheries Research, started a program of reevaluating the trawl fishery to determine the condition of the fishery and compare the results with those obtained by Warfel and Manacop (1950). Observations on the otter trawl fishery of Manila Bay which were started have yielded some noteworthy results and are being continued to the present.

This report is based on the results of the study during the first three-year period from 1957 to 1959. A total of 66 fishing trips, aboard 35 commercial vessels, was undertaken by the members of the technical staff of the Section of Hydrology and Fisheries Biology who joined these fishing trips fortnightly for 3 to 5 days at most. Data collected from these fishing cruises were used in this report.

The otter trawls are normally operated in the deeper parts of not less than 7 fathoms in Manila Bay. They use nets of the converted beam trawl type and are called the *mestizo* type of net. The mesh size of the cod ends of the nets ranges from 1 to 1½ inches with the nets themselves measuring from 50 to 65 feet on the headrope. Recently, with the introduction of the twin-engine trawlers in Manila Bay this type of net has proved most effective.

For our study, observations on the following were made: size and power of fishing vessels, the catch composition, total catch landed, analysis of the monthly catches, recent improvements in the otter trawl, and the catching ability of different sizes of trawling vessels. Surface and bottom water samples are taken for salinity and phosphate studies, and data on temperature are recorded during the hauling of nets. This hydrographical portion of the study will be discussed in the final report.

SIZE AND POWER OF FISHING VESSELS

The otter trawl fleet operating in Manila Bay in 1957 consisted of 50 trawls operating monthly on the average, with a total of 604 boat-months operating during the year. There has been a slight increase in the number of boats in the

TABLE 1.—*Number of otter trawls operating in Manila Bay.*

Year	Average number of boats operating monthly	Number of boat months per year
1957	50	604
1958	53	637
1959	56	669

fishery, increasing the boat-months per year correspondingly (Table I). Each trawler is of the launch type, which was originally a war-salvaged tugboat, a "W and T" or a "PT" boat, converted for trawling. In 1958–59 the twin engine

was introduced into some trawlers. This increased the cruising speed from 3 to 4 knots per hour. In 1960 this was widely accepted and adopted by this industry.

The engine now commonly used is a 125–h.p. *Greymarine* with a normal towing speed of 1½ to 2 knots. A great number of trawlers are locally constructed vessels of *sampan type*. All the vessels used for this study ranged from 32 to 65 gross tons.

CATCH COMPOSITION

The catch of the otter trawlers consists of a great variety of fish numbering over 100 species representing more than 30 families, so that a detailed sorting is not possible. The grouping used by the fishery in sorting the catch as soon as it is hauled follows. The fish are sorted and placed in wooden trays in single layers and iced. The catches are roughly sorted into groups depending mostly on size, namely:

1. *Hoya*—consisting of first class fish (pomadasids, lutjanids, carangids, groupers, and others);
2. *Halo*—consisting of second class fish (nemipterids and goat fishes, and others);
3. *Samot*—consisting of third class fish (mojarras, small hairtails, and others);
4. *Sapsap*—slipmouths of several species;
5. *Kalaso*—lizard fishes of several species;
6. *Hipon*—shrimps of several species; and
7. *Pusit*—squids

However, for purposes of this study, sorting was done in six categories, namely: (1) *hoya* (2) shrimp (3) squid (4) slipmouth (5) lizard fish (*Saurida*) and (6) miscellaneous. Figure 1 shows the monthly breakdown of catches in kilograms per 10-hour drag (in per cent) for the years 1957 thru 1959, based on an average of two trips per month.

Hoya.—Perusal of the data based on the catches separated into the six categories seems to indicate that for the three-year period under review, the catches in 1959 have a high percentage of first class fish *hoya* forming from 35% to 41% of the total catch.

Normally, during the period from 1957 to 1958, this group fluctuated from 22% to 37% except in April when a high

percentage of 57% was recorded. It was noted also that there is a higher catch of this group during the start of the dry season (October to November) probably indicating a higher concentration of the larger fish in the deeper water preparatory to spawning migration outside of Manila Bay.

Shrimp.—It appears that the shrimp resources have dwindled greatly during 1959. The catch of shrimps is closely associated and was highly correlated with the rainy season. While the shrimp catch in 1957 was from 8.5% to 14.7%, the highest percentage being taken in August, it was between 7.5% to

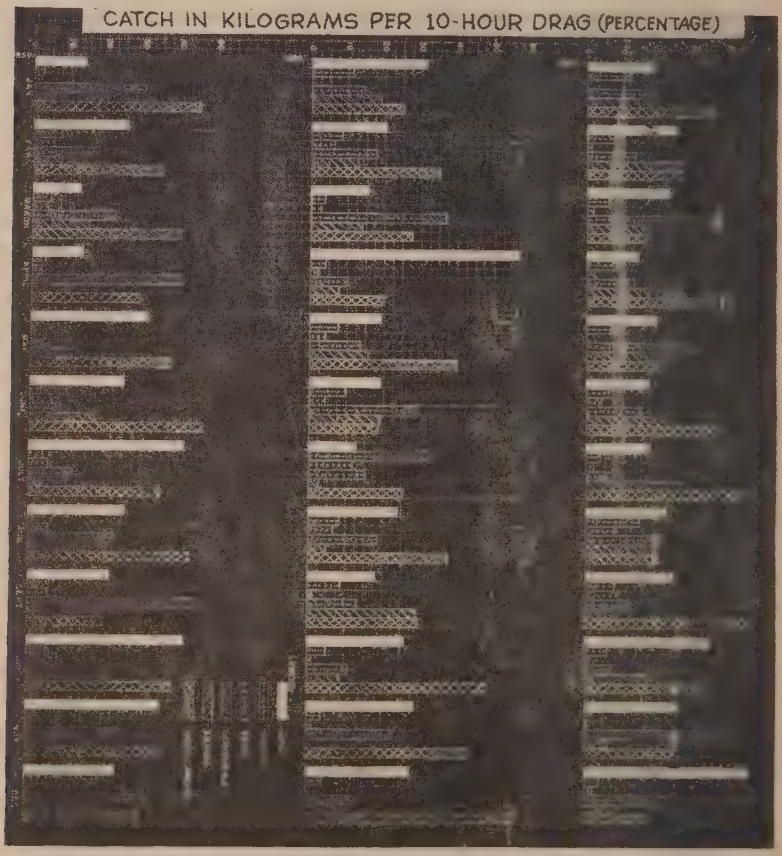

FIG. 1. DISTRIBUTION OF THE CATCHES OF OTTER TRAWLERS IN MANILA BAY IN KILOGRAMS PER 10-HOUR DRAG FROM 1957–1959 IN PER CENT.

32.5% in 1958, the highest being in July. It also has the highest percentage yield of a single group during the month.

However, in 1959, the shrimp catch dwindled to as low as 1.5%. The lowest then was during the month of August. It appears that during this year, the percentage of shrimp caught during the dry season was higher (October–7.7%) than during the rainy season contrary to what has been observed in the two preceding years.

Squid.—Small quantities of squids are taken by trawl and in 1957, the months of August and September showed a percentage of squid catch, 8% and 9%, respectively.

In 1958, the catch during the first half of the year was nil except in February. The highest was during the months of July and August. During 1959 the squid catch was high most of the months, the highest being in October. The lowest was in June. From this data, it appears that squid is a sporadic visitor of the Bay probably entering the Bay in shoals depending upon the available food supply or species of small fish on which they depend upon as food. Although it is expected that as a pelagic species it could be prevalent during the summer months when the water salinity is high, the fact that during some years, the maximum catch occurred during the months of low water salinity shows that the presence of squid in the Bay depends more upon the available food supply and/or prevailing water currents carrying food organisms.

Slipmouth.—In 1957, a high percentage of *Leiognathus* was recorded during the months of March, May, August, November, and December, followed alternately by months of low catches. During 1958, the highest catches were made in March, June and November, and in 1959, in January, April, August, September, November and December. The data on *Leiognathus* species catch show the importance of this group as the mainstay of the trawl fishery in Manila Bay. A definite trend is noted in which there appears a cycle of high and low catch showing variable availability of the group which may run much lower than $\frac{1}{4}$ to $\frac{1}{2}$ of the peak of the cycle. As has been shown by analysis of the catch composition of the trawl by species of *Leiognathus,* definite species may become predominant for one period and disappear totally from the catch after reaching a peak of abundance only to be replaced by another species which may then become dominant a few months later. Perusal of the months when *Leiognathus* species was predominant in

the catch shows no correlation with the rainy or dry season. More studies are needed to determine the causes of variation in availability.

Lizard fish (*Saurida*).—This is one of the most important groups of fish taken by otter trawls, the catch being high during the dry season from 16.7% to 26.2% and decreasing during the wet season. In 1958, while the catch was also high during the first half of the year (dry season) and devendled slowly during the second half, a very high average (29.0%) was recorded for the month of September which is the highest for the group during the period under review. In 1959, there appears to be a great decrease in the availability of lizard fishes and except for the catch in March (15.2%) and in June (17.1%) the percentage composition of the lizard fishes was in most cases below 10% and in fact just above 1% during October and November indicating a great decrease in the lizard fish population.

Miscellaneous Fish.—The great bulk of the catch consisting of small sizes of the various species available to trawlers are classified under this group. In almost all months of the year throughout the period under review, this group forms a big portion of the catch. In 1957, for example, for 8 months during the year, the catch percentage fluctuated from 46.4% in July to 24.6% in November whereas in 1958, for 10 months, the catch was from 24% in July to 55.9% in December. In 1959, for 10 months the group formed the dominant catch of the total landings. This volume of catch indicates that the miscellaneous group taken by trawling in Manila Bay, is really a form of industrial fishery for fish meal comprising about ⅓ to almost ½ of the total catch. Nevertheless, only a small percentage of this group is converted into fish meal because the majority of the catch is sold in the public market or if in poor condition of preservation, it is sold for the manufacture of fish sauce.

CATCH LANDED

Table II shows the average monthly landings of otter trawlers operating in Manila Bay for the three-year period based on the average catches of vessels which had been accompanied by our research team during the fishing operations. A definite trend of decrease in the catch per hour drag has been noted from the start of the study in 1957 which was 16.16 kgs. (per hour drag) to 12.15 kgs. in 1959. This may

be attributed to the increase in the number of units that operated from 1957 to 1959, and a proof of overfishing in the area.

TABLE II.—*Average landings of Otter trawls in Manila Bay in 1957–59.*

Year	Catch rate per hour	Monthly average landings	Annual average landings
1957	16.16 kgs.	546,176 kgs.	6,554,116 kgs.
1958	13.32 kgs.	509,066 kgs.	6,108,798 kgs.
1959	12.15 kgs.	506,658 kgs.	6,079,903 kgs.

The average monthly and annual landings which are related to the number of boats in operation show a downward trend in the average catch in 1959 indicating that the fishery has probably reached its maximum development, such that adding more fishing vessels has not increased but rather decreased the annual average landings of the previous years. Because of this development, in 1960 there has been an exodus of trawlers to fish outside Manila Bay.

ANALYSIS OF MONTHLY CATCH

Table III shows a comparison of the monthly landings of all trawlers operating in Manila Bay for the three-year period. It may be noted that there are more trawlers in operation during the second half of the year than during the first half. This may be explained as follows:

TABLE III.—*Computed monthly trawl landings in Manila Bay as average from the three year data (1957–59).*

Month	Average number of boats operating per month	Monthly average catch per boat in kilograms	Computed average monthly landings of all trawlers
January	49	7,867 kgs.	382,632 kgs.
February	48	6,814	322,233
March	47	10,786	505,382
April	50	10,730	543,689
May	60	10,225	620,027
June	48	9,034	432,917
July	53	9,191	487,068
August	51	9,908	501,959
September	57	9,482	534,202
October	58	12,638	713,125
November	58	12,269	719,688
December	59	8,033	491,685

During the first half of the year when the Northeast monsoon is on, many trawlers fish outside of Manila Bay going to the southern fishing grounds because of favorable weather

conditions allowing them to fish farther. During the later part of the year, the Southeast monsoon prevents the fishing vessels from fishing outside Manila Bay. It will be noted, however, that the higher average catch per vessel is made during the months of October and November at the termination of the SW monsoon season. This season brings rain which has contributed a great amount of runoff adding to the fertility of the bay waters. This higher catch after the monsoon season may also be explained by the inefficient trawling operations during the months when the SW monsoon is on and the typhoons are most prevalent making trawling difficult. It is interesting to note that the least average catches are made on December, January and February which also coincide with the coolest months of the year. However, larger and better fish (hoya) are caught during the same period. Whether the water temperature has an effect on the availability of bottom fish in the Bay has not yet been established. However, immediately after the onset of the dry warm months, March, April, and May, the average catch per vessel increased much more than the average catch during the cooler months of the year. The average catch of 9,000 tons during the rainy months from June to September, appears to be fairly uniform.

RECENT CHANGES IN THE MANILA BAY FISHERY

After 1959, many trawl operators noted that a decreasing amount of catch per unit effort was apparent. This led to changes in the trawl fishery of the Bay in the following direction:

1) an increase of trawling power of vessels by installing an extra engine, thereby increasing the towing power twice.

2) a total abandonment of the trawl for *basnigan*, (bagnet fishery) a better and more lucrative gear suited for pelagic fishing outside Manila Bay.

It has been noted that the otter trawlers in Manila Bay and basnigan vessels operating in northern Palawan are primarily owned by the Navotas–Malabon fishing community at the suburbs of Manila. Very recently, the upsurge not only in the size of vessels but also in the number of units and carrying capacity of the bagnet gear may be correlated with the decrease of otter trawlers operating in Manila Bay.

The introduction, therefore, of the twin-engine otter trawlers in Manila Bay in 1960 was a success, for pelagic fish species,

which used to be caught only sporadically by this gear, as roundscad, *Decapterus;* chub mackerels, *Rastrelliger;* gizzard shads, *Anadontostoma chacunda;* and sardines, *Sardinella* formed a major catch of the trawlers and preliminary results showed that there is an apparent increase in the catch rate to 13.7 kgs. per hour drag in 1960. At the moment, therefore, there is a greater trend for the conversion of single-engine to twin-engine trawlers.

Since then, there has been a consistent increase in the quantity of pelagic fishes caught by trawlers indicating the success in the use of more power for otter trawlers to enable them to catch more pelagic species. Inasmuch as great speed has a tendency to raise the net from the sea bottom the catch of shrimps has dwindled correspondingly during the period.

A COMPARISON OF THE CATCHING ABILITY OF FOUR TRAWLERS OF DIFFERENT SIZES OPERATING IN MANILA BAY

A comparative study of four otter trawlers was conducted to determine the catching ability of each size group. These vessels represent various types of the majority of otter trawlers operating in Manila Bay. Table IV shows the fishing vessels selected for this purpose.

TABLE IV.—*Comparison of four types of otter trawlers used in Manila Bay*

Name of boat	Weight gross ton	Length meters	Trawling power or capacity horse power	Engine type
1. Ildefonso I	18.77	17.15	80	Kinoshita
2. Ildefonso IV	48.37	29.59	80	Kobe
3. Leonor V	60.43	20.44	160	Superior
4. Doña Luisa D	83.85	22.00	325	Atlas Imperial

The representative fishing vessels selected were of varying engine power. The M/V *Ildefonso I* and the M/V *Ildefonso IV* are equipped with slow-speed, heavy duty engines; whereas the M/V *Leonor V* and the M/V *Doña Luisa D* are equipped with high-speed, heavy duty engines.

All these fishing boats use the commercial otter trawl net of the *mestizo* type, with a size of 65 to 80 feet on the footrope. The mesh size on the cod end of their net varies from 1 to 1.5 inches.

Figure 2 shows the superiority of M/V *Doña Luisa D* in the catching ability test over the other fishing boats under study. Owing to its powerful engine, it can attain a faster towing speed. This boat is quite efficient in catching the more elusive, bigger and fast-swimming pelagic species, but not so efficient in catching shrimps, squids, and other mud-burrowing species. The M/V *Leonor V* fishes similarly as the M/V *Doña Luisa D*, although not as powerful as the latter. On the other hand, the slow-towing fishing vessels, the M/V *Ildefonso I* and the M/V *Ildefonso IV* can hardly get the more elusive, pelagic, fast-swimming species, but are quite efficient in catching shrimps, squids and mud-burrowing fish (flatfishes, turbots, lizard fishes, etc.).

From this comparative study, the following observations were noted:

1. The faster the towing speed of the fishing vessel, the more efficient it is in catching the pelagic species, as *Rastrelliger*, *Decapterus* sp., etc., and the fast-swimming large species, as the leather jacket (*Scomberoides*), barracudas (*Sphyraena*), porgy (*Lethrinus*), *etc.*

2. On the other hand, the slow-towing fishing vessels, are more efficient in catching shrimps, squids and mud-burrowing fish or slow-moving species, as the lizard fishes, turbots, soles, etc., because the net can scrape the sea-bottom better.

From these observations, the fisherman can adjust or select the type of engine suitable for use in the fishing ground, depending on the species commonly available in the area.

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TIEWS, K. AND P. CACES-BORJA 1959. On the availability of fish of the family Leiognathidæ Lacepede in Manila Bay and San Miguel Bay and on their accessiblity to controversial fishing gear Phil. Jour. of Fisheries, Vol. 7, No. 1 pp. 59-87.

ILLUSTRATION

TEXT FIGURE

FIG. 1. Distribution of the catches of otter trawlers in Manila Bay in kilograms per 10-hour drag from 1957–1959 in percent. 57

CONTRIBUTION TO THE INVESTIGATIONS ON THE OSMOREGULATION IN FISH EGGS.*

By Elvira O. Tan

Of the Philippine Fisheries Commission

SIX TEXT FIGURES

Some studies were made so as to understand the fate of some marine organisms that inhabit bodies of water, both very saline and brackish as it is between the North sea and the Baltic sea which have given rise to several physiological problems.

The physical properties studied were the specific gravity and diameter changes taking place on some fish egg species most common in the Baltic sea and the North sea. The spawning season of the species studied takes place from December (November) to July (August) of each year. The spawning period for each species lasts from 2 to 4 months, some of them overlapping each other.

Number of eggs of the different species in which the specific gravity and the diameter were examined:

Species	In original salinity determination		In different salinities determination	
	Specific gravity	Diameter	Specific gravity	Diameter
cod	279	1,603	375	562
onos	478	432	417	93
dab	208	185	142	74
plaice	63	89	62	27
flounder	21	22	20	
mackerel	173	149	108	21
sprat	89	106	41	

(By "original salinity" is meant, where the eggs themselves were fished (about 20 meters deep) by plankton egg net and "different salinity", when the eggs were transferred for definite length of time to other salinities except where they were originally found).

* A summary of the Thesis "Untersuchungen ueber die Osmoregulation pelagischer und demersaler Fischeier" performed and submitted at the Institute of Oceanography (Inst. f. Meereskunde) of the Christian Albrechts University in Kiel, Germany, in partial fulfillment of the degree of Doctor of Natural Science. The whole paper will be published in one of the European Journals.

Considering the chemical changes following the physiological behavior of the eggs the water, sodium, potassium, chloride and phosphorous contents and their changes with changing salinities of environment were examined. In this investigation not only pelagic eggs were investigated but also demersal marine and fresh water species. Like those in the examination of the physical characteristics the eggs were differentiated not only as to species but also according to the stage of embryonal development in the eggs and all investigations were performed at definite temperature.

Number of analysis made:

Species	H_2O, Na, K, P, and ash	Chloride
cod:		
ovarian	12	12
fertilized	113	109
unfertilized	41	30
dab:		
fertilized	17	20
flounder:		
fertilized	16	9
cottus:		
ovarian	23	16
fertilized	75	72
pike:		
ovarian	4	4
fertilized	15	17
unfertilized	19	19

Sodium and potassium were analyzed by the Flamephotometric method, chloride, by the micrometric method of Rehberg and phosphorous, by colorimetric method using a spectral photometer.

Pelagic fish eggs of the different species vary in their specific gravity not only between species but also within the same species and even among individuals. According to the specific gravities, the fish eggs examined may be grouped into light, intermediate and heavy eggs. Under light eggs are seequabbe and plaice; intermediate: mackerel, cod and sprat; and heavy eggs: flounder followed by dab.

Specific gravity is related to some degree to the salinity of the surrounding water, (fig. 1) which may differ from the latter by minus 1 per cent to 3 per cent. The salinity of the water affects the specific gravity, volume and even the ion concentration of the eggs very early in its development or formation. This effect could already be traced from the ovarian eggs of fishes living in different degrees of salinity. Those living in low salinity waters produce eggs in which the above mentioned

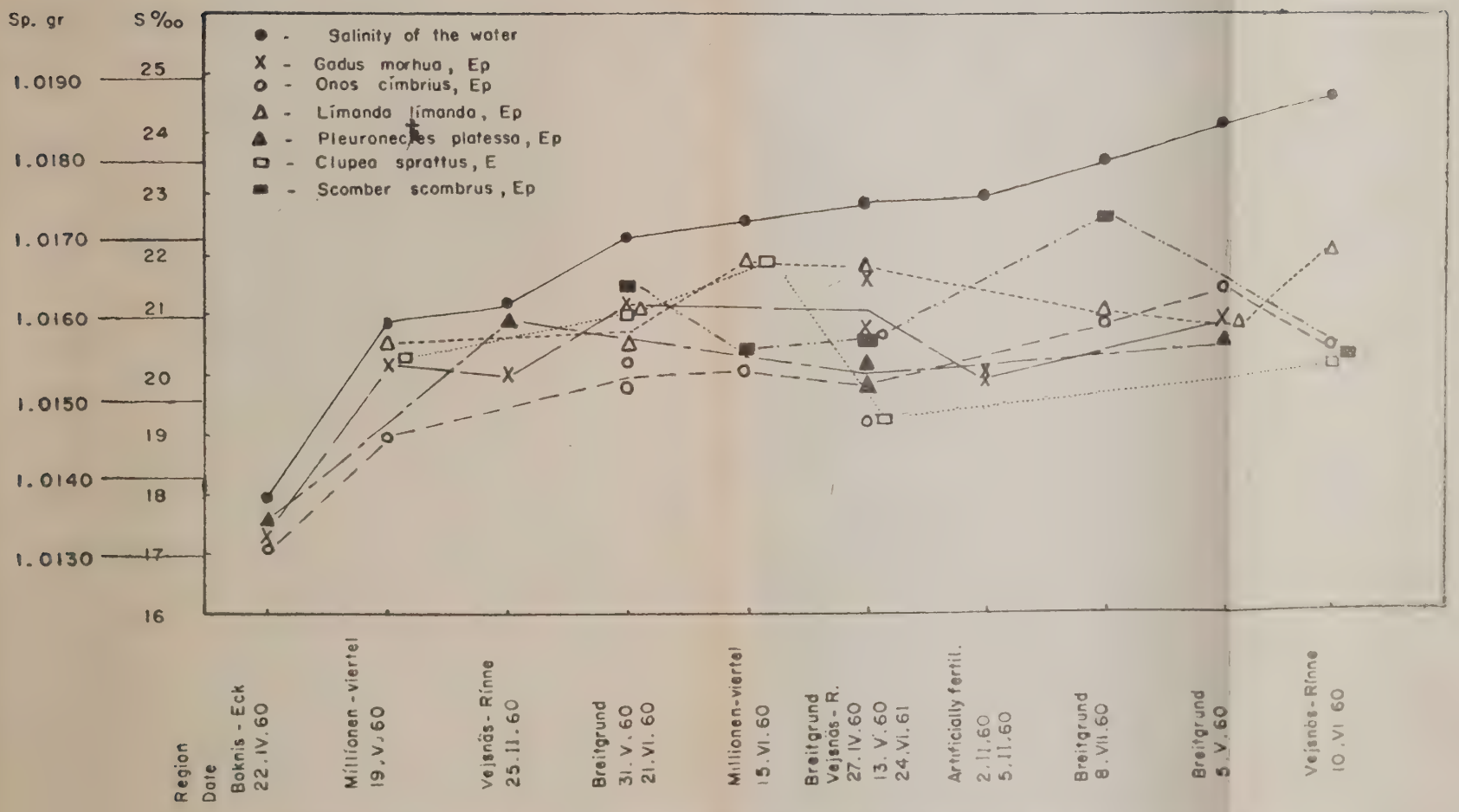

FIG. 1. Specific gravity (Salinity ‰) of pelagic fish eggs sampled from several localities with varied water salinities.

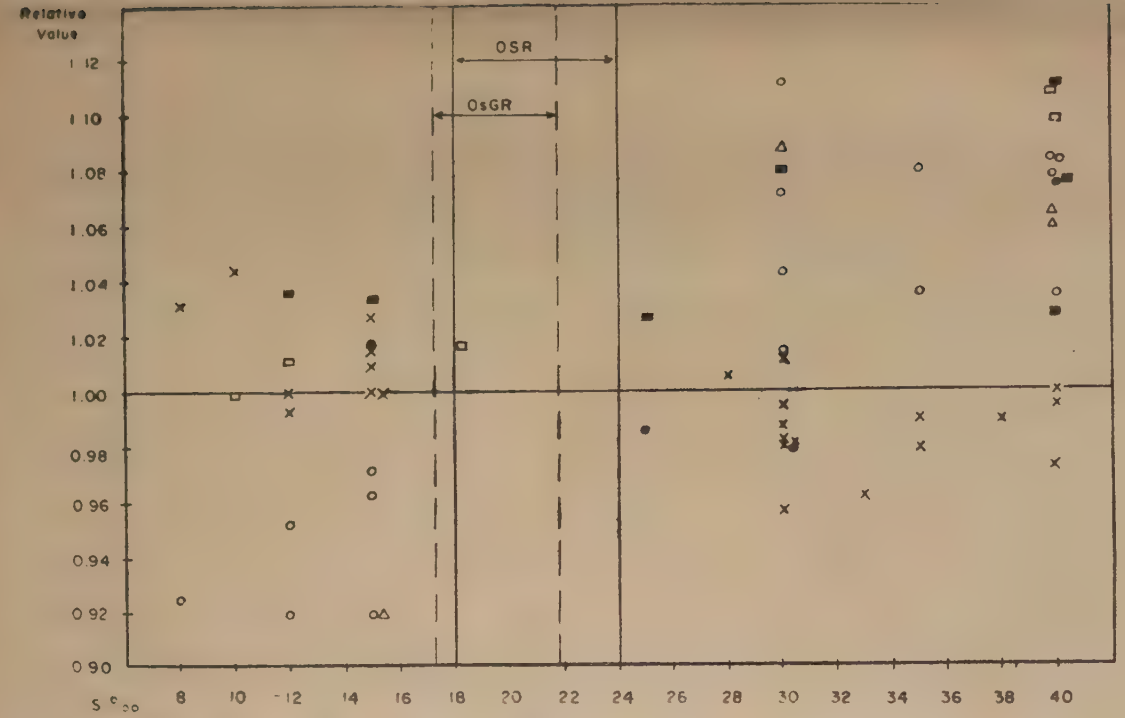

FIG. 2.—Average changes in the specific gravity and volume of the Code (Gadus morhua, L.) eggs following transfer to water of different salinities:

characteristics are lower to certain limits and on the other hand those living in more saline water have eggs which also have somewhat higher percentage of these traits, (Fig. 5).

In spite of this the specific gravity of the eggs and also the other characteristics after laying are not fixed. They vary still to a limited degree, with the stage of development of the egg and with the change of salinity of the surrounding. In relatively low salinity there is lowering of the specific gravity, increase in volume (diameter) (Fig. 2), and lowering of ion concentration and also a small increase in water content, and the reverse in higher salinity takes place. The different egg species behave differently, such as, seequabbe eggs which do not show lowering of the specific gravity with reduction of the salinity by 10 per cent, but upon transfer to higher salinity of the same degree as stated, they produce an increase in specific gravity and decrease in volume; cod eggs react almost symmetrically towards transfer to low and high salinities; sprat could tolerate to a certain extent, like seequabbe, reduction of salinity without showing much changes. Mackerel could well tolerate increase in salinity, just as the above species behave with lowering of salinity.

Critical stages in the egg's life are the stage during the early cleavage and the stage shortly before hatching. It seems that at these points or stage, eggs react very poorly towards changes in environment, aside from the environment where they were. It may be said that at this stage the eggs could not properly exercise their osmoregulatoric function, which at other intermediate stages could excellently be performed.

The ripe ovarian eggs of the pelagic type have large quantities of water from about 93 per cent to 95 per cent. Those of the non-pelagic marine type have about 80 per cent and the fresh water species have only approximately 70 per cent, (Fig. 3).

The initial increase of water content and ions after laying of the salt water species is large in comparison to the succeeding stages. Within 24 hours in the medium, the water content in the eggs remains constant, and the ions, also, to a certain degree. Then, during the stage before hatching, there is slight increase in water, sodium and potassium also to a limited extent, but the chloride remains either constant or decreases slightly, (Table 1). At this stage no change of salinity of water was made.

The water content changes only minimally with change of salinity, but the ions, especially sodium and chloride, and to a

TABLE 1.—*Water content and ion concentration of the Cottus Bubalis eggs of different stages of development in water of 15°/00 Salinity*

Egg stage	Number of analysis	% Water	In % Fresh weight					In dry weight		
			K	Na	P	Cl	Ash	K	Na	P
Ovarian	10	78.68±.30	0.151±.003	0.175±.004	0.129±.003	0.406±.016	0.79±.020	0.703±.017	0.821±.018	0.604±.013
1 hour	7	79.99±.19	0.155±.005	0.184±.007	0.114±.008	0.585±.018	1.00±.034	0.773±.026	0.919±.035	0.572±.012
6 hours	7	80.75±.11	0.185±.005	0.225±.005	0.109±.002	0.599±.014	1.13±.044	0.961±.029	1.170±.037	0.564±.010
24 hours	9	80.34±.22	0.134±.003	0.253±.009	0.114±.002	0.658±.012	1.18±.036	0.682±.016	1.285±.038	0.578±.007
Spawn [1]	5	79.80±.40	0.139±.004	0.264±.012	0.130±.011	0.649±.017	1.25±.055	0.687±.010	1.275±.041	0.657±.019
Ep	2	81.40±.61	0.108±.009	0.234±.02	0.105±.008	----------	1.24±.055	0.578±.029	1.260±.054	0.561±.019
Ea	3	81.92±.17	0.124±.003	0.371±.011	0.107±.005	0.568±.012	1.64±.039	0.685±.015	2.055±.079	0.591±.003
Ea [2]	1	82.02	0.119	0.457	0.109	----------	1.45	0.661	2.541	0.606

[1] Egg spawned naturally in the water, so that the exact length of time of its stay in the medium is not known, possibly between 20 27 hours after laying.

[2] Ea stage eggs in which the heart beats of embryo is strong and very clearly seen.

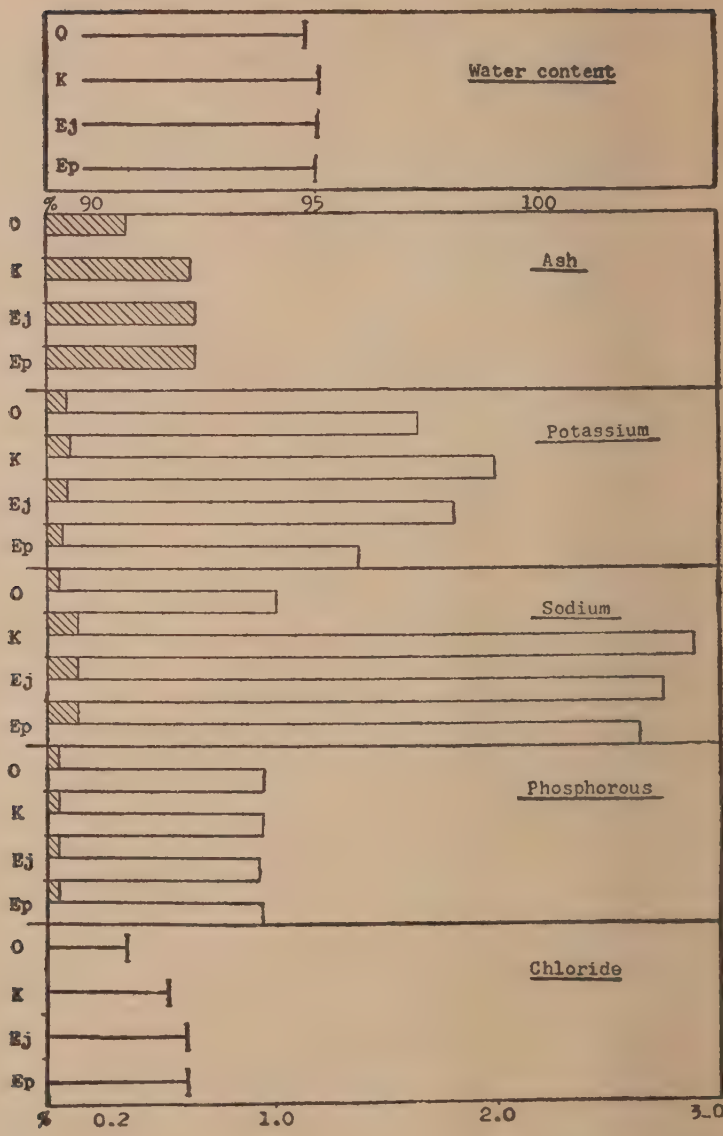

FIG. 3. Composition of the Cod (Gadus morhua, L.) eggs at different stages of development. O– ovarian eggs, K to Ep are stages of fertilized eggs in water of 25% S., ▨ % in fresh weight, □ % in dry weight. Taken from samples **D–3,–3a,–4,–5 and –5a.**

smaller degree potassium changes exceedingly during all stages accompanying change of salinity (Fig. 4). The changes found for the ions were all significant changes.

The salinity of the water where the fish, (*Cottus bubalis*), is cultured affects the properties of the eggs to be laid. In relatively low salinity the ripe ovarian eggs have higher precentage of water and in relatively saline water, smaller and the ions vary more or less in the reverse way, (Fig. 5). The chloride content in the three different salinities, 5, 15 and 30 parts per thousand differ significantly. In the 15 and 30 parts per thousand bracket, the concentration of ion sodium does not vary significantly. In 5 parts per thousand the variation is significant. This is also true with potassium. Whether the fish lived or were cultured in low or highly saline waters, the eggs upon contact with the medium shows increase water content in the cell and sudden changes in ion content occur (Fig. 6).

The fresh water pike eggs exhibited an impermeable stage during development of the embryo. After the first initial increase of water after laying and very minimal decrease in some of the ions, the concentration of these substances remained constant till shortly before hatching.

Therefore it may be concluded that fresh water fish eggs are practically independent of their hypotonic surrounding and the same independence is true for marine eggs with regard to their strongly hypertonic environment.

Potassium is higher than sodium in the ovarian eggs of most fishes. The latter upon contact with sea water becomes higher than the former. With fresh water species the relation remains the same before and after laying. But with Seeskorpion the relation of the two ions is almost 1: 1.2 (K: Na).

The quantity of phosphorus in the egg remains more or less constant after a small lose immediately after laying, which is true for all species.

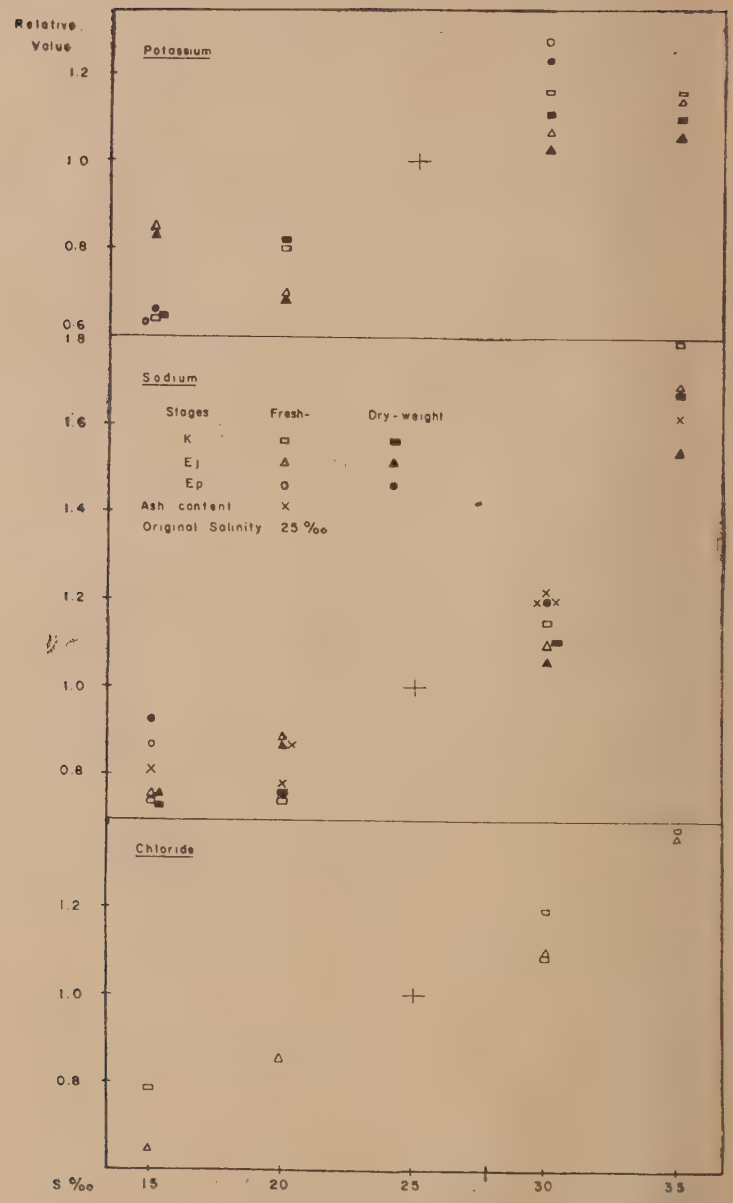

FIG. 4. Changes in the ion content of cod. (Cadus morhua, L.) eggs 24 hours following transfer to other salinity. The content at 25‰ as taken as 1.

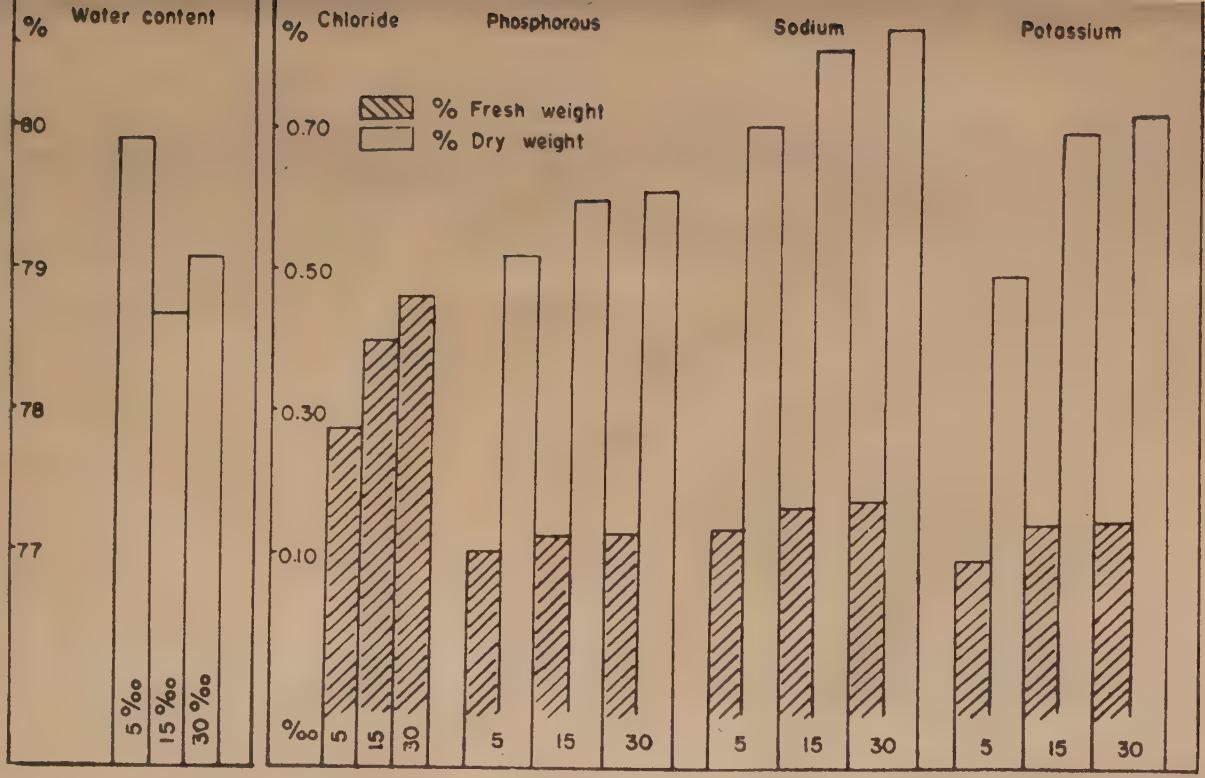

FIG. 5. Composition of the ripe ovarian eggs of Cottus bubalis, L. The fish were cultural in water with salinities of 5‰, 15‰ and 30‰.

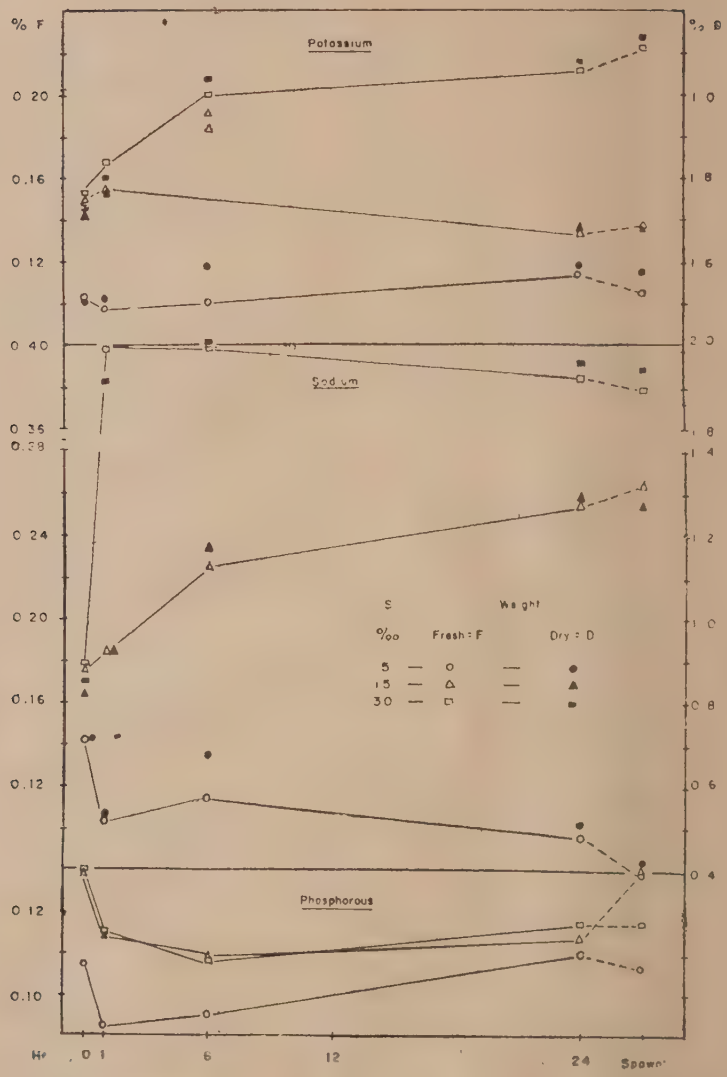

Fig. 6. Ion content of the eggs from Cottus bubalis cultured in water of different salinities and after their eggs had stayed in these salinities for definite length of time.

ILLUSTRATIONS

SIX TEXT FIGURES

FIG. 1. Specific gravity (Salinity $^0/_{00}$) of pelagic fish eggs sampled from several localities with varied water salinities.

2. Average changes in the specific gravity and volume of the Cod (Cadus morhua, L.) eggs following transfer to water of different salinities.

3. Composition of the Cod (Cadus morhua, L.) eggs at different stages of development.

4. Changes in the ion content of Cod (Cadus morhua, L.) eggs 24 hours following transfer to other salinity.

5. Composition of the ripe ovarian eggs of Cotton bubalis, L.

6. Ion content of the eggs from Cottus bubalis cultured in water of different salinities and after their eggs had stayed in these salinities for definite length of time.

AGE AND SIZE AT SEXUAL MATURITY OF WHITE GOBY (GLOSSOGOBIUS GIURUS), A COMMON SPECIES OF FISH OF LAGUNA DE BAY, WITH NOTES ON ITS FOOD HABITS [1]

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THREE PLATES AND SIX TEXT FIGURES

ABSTRACT

The pronounced depletion of the goby fishery of Laguna de Bay after 1950, probably resulting from the use of a non-selective fishing gear, the *seket*, initiated this study of the *biyang puti* (*Glossogobius giurus*).

The analysis of the length frequencies of 3,768 specimens, the examination of the ovaries of 1,019 female specimens and the measurement of the diameters of 3,233 ova formed the bases for the determination of the age and size at first sexual maturity of this species, collected from the Cardona and Taguig areas of Laguna de Bay, from August 1958 to August 1959.

The fish, on the average, matures at the end of its first year of life at size range 105–114.9 millimeters. The expanded or multiple spawning habit is characteristic of the species. However, maximum spawning activity takes place from June to August. Mature eggs measure from 0.55 to 0.83 mm. in diameter. Although the detailed study of the sexual maturity stages of the male *biyang puti* was not done, yet a close correlation with the maturity stages of corresponding female size groups was observed.

It was found from the 161 stomachs examined that although *biyang puti* is predominantly a vegetarian, yet it also utilizes zooplankton forms and other miscellaneous food items. Furthermore, it is at the same time a piscivore, feeding on its own kind. There is no significant variation in the kind of food items taken in by the different size groups. The presence of an unidentified fluke in the majority of the size ranges of fish examined suggests a case of parasitism which might be worthy of future study.

INTRODUCTION

The *biyang puti* or white goby, scientifically known as *Glossogobius giurus* (Hamilton Buchanan), is the largest and most important of Philippine gobies and is a valuable food fish in many fresh water units of the country. It used to be the most abundant and, therefore, most important fishery of Laguna de

[1] Excerpts from a thesis presented to the Faculty of the Graduate School of the University of Santo Tomas, in partial fulfillment of the requirements for the degree of Master of Science in Zoology, March, 1962.

Bay. After the Second World War (1945–49) the condition of the fisheries resources of Laguna de Bay which consisted of some 17 species of fish, five species of crabs and shrimps, and six species of clams and snails, (Francisco 1959) began to decline, probably because of greatly increased demands on the fishery, leading to over-fishing and to the use of new non-selective gear which were destructive even to smaller fish. All these show total disregard to sound fishery conservation practices as observed in western countries.

Since 1950, the destruction of the goby fishery of Laguna de Bay has become pronounced because of the use of the goby dredge-trawl or *kaladkad pambiya*, the *seket* and the *pukot*. To remedy this serious problem, the Secretary of Agriculture and Natural Resources, under Special Order No. 45, dated August 28, 1958, created a survey committee to make a study of the fishing and duck-raising industry problems in Laguna de Bay. One of the most important recommendations made by the survey committee (Francisco *op. cit.*) was the banning of the use of *seket* and *pukot* for one year, *i.e.*, from January 1 to December 31, 1959. However, it is believed that the implementation of this recommendation would not be successful, unless the more important aspects of the biology of the commercial species of fishes concerned are well understood.

A study of the age and size at first sexual maturity of the *biyang puti*, an important commercial fish species of Laguna de Bay, including a study of its food habits, was therefore felt essential for the better understanding and promulgation of remedial measures for the conservation or rehabilitation of this particular fishery.

THE "BIYA" FISHERY IN LAGUNA DE BAY

Although Laguna de Bay is considered the largest fresh-water lake in the Philippines, with an area of 930.7 square kilometers, and with about thirty municipalities (see also plate 1) located around its shores in Laguna and Rizal provinces, yet its fishery resources at the moment cannot adequately provide fish to a population of no less than 400,000 inhabiting the lake shores, due to lack of proper husbandry of this body of water. To this segment of population, the *biya* contributes an important role in its dietary protein requirement. It was this disheartening situation that prompted the Bureau of Fisheries to conduct an

investigation of the conditions obtaining in the lake sometime in 1959. Bersamin (1959) described the ecological conditions of Laguna de Bay as follows:

1. The plankton content of the water was high. The blue-green algae and diatoms were consistently abundant.
2. The turbidity readings indicated a high concentration of plankton present in the water.
3. The pH ranged from 8.1 to 8.9, representing the normal limits in tropical lakes.
4. The temperature of the water fluctuated from 25°C to 29°C and that of the air, from 24°C to 31°C.
5. Salinity reading was zero for the whole period of investigation.
6. The oxygen determinations made from various depths were above 5 parts per mile, showing that the supply was sufficient for the normal growth, development and multiplication of the animals living in the lake.
7. There were no severe fluctuations in the water level during the year.
8. All environmental influences were on the optimum level.
9. Soil erosion was not evident.
10. The bottom was sandy-muddy.
11. In nearly all places, there was an abundance of dried *lumut* which were several layers thick along the shore, together with water *hyacinth, Eichornia crassipes,* and to a lesser extent *Chara, Vallisneria, Hydrilla,* Digman, etc.
12. The condition of the fishes examined revealed that they were well nourished.

Because the aforementioned ecological conditions were, and have been, known as the norm for Laguna de Bay, it became clear that the apparent depletion of the lake was due to the increasing fishing pressure on the lake by too many fishermen, leading to overfishing, especially through the use of destructive fishing gears.

It has been estimated that in 1959 the capital investment in the *biyang puti* fishery of Laguna de Bay was no less than ₱400,000.00. At the close of 1950, the goby dredge-trawl, *kaladkad pambiya* fishery became established along the Rizal side of Laguna de Bay. The *kaladkad pambiya* is a combination of an indigenous dredge-trawl gear operated on a motorized banca. Together with this gear, the other *biya-catching* devices, like *pukot, seket, bubo,* and *baklad,* have been used extensively. Among these gears, the *seket* has increased in number and has recently become the most common gear used in the lake.

The census of 1958 revealed a total of 184 *seket* units in Laguna and Rizal Provinces operating in Laguna de Bay. Out

of this number, 165 were motor-powered and 19 were non-powered. Widespread complaints were lodged by the fishing inhabitants around Laguna de Bay areas against the destructive effects through use of *seket*. Felix and San Antonio (1959) described the *seket* operation as a means of livelihood for a large segment of the inhabitants in the towns of Cardona, Tanay, Binañgonan, Angono, and Taguig in Rizal Province, and Sta. Rosa, Bay and Sta. Cruz in Laguna. Although the design varies somewhat in different fishing areas, the principle of operation is fundamentally the same, i.e., impounding the fishes after a *round-up*, brought about by the use of a scareline, live-boxes, scoop-net and boats. The number and size of boats used in the operation may be two or three, depending on the type of net used.

The *seket* is usually operated during daytime, depending on the place of the fishing ground and market. Catches are usually good during calm weather when the water is generally clear. Prevailing strong winds cause big waves which disturb easily the bottom, thus causing turbidity of the water. Clear water, however, increases the visibility of the mud clouds produced by the scareline, scaring the gobies towards the net and leading to more catch.

Each fisherman (normally seven persons form a team) is paid in *share* and *share alike fashion* after deducting all the operating expenses, such as fuel, rice, cigarettes, etc., from the gross sales of the catch. One share goes to the net, the livefish box and small banca; another share to each motor-banca, and, then share each to every fisherman. Previously each fisherman received a share ranging from ten to thirty pesos daily. This was much better than the present practice of daily shares which ranges from only five to twenty pesos as revealed by the fishermen themselves. (Felix and San Antonio, *op. cit.*)

REVIEW OF LITERATURE

Published reports on the study of the habits and life history of Philippine gobies are still few. This is particularly true of the studies on age and size at sexual maturity of Philippine fishes. Manacop and Capco (1955) described the goby dredge-trawl fishery of Laguna de Bay and noted that the mean standard length at sexual maturity of *biyang puti* is 125 millimeters. They also determined the mean size in a separate study undertaken during the same period of investigation of the goby dredge-trawl fishery. This is the only available reference that deals

with the size of *biyang puti.* Manacop (1953) reported on goby (*Anga*) *Sicyopterus extraneus,* stating that the size at first maturity in both sexes varied and that the adults fed primarily on various kinds of algae, particularly on the pennate diatoms.

Blanco (1956) reported on the general biology of the gobies that constituted the goby fry for *ipon* fisheries of the Laoag River and its adjacent marine shores. In this river, six species of gobies composed the bulk of the post-larval stages of the fishery during the September-December 1954 and January-February 1955 *ipon* seasons. These were *bukto, Chonophorus melanocephalus; bunog, Chonophorus ocellaris; virot, Eleotris melanosoma; balla* or *biya, Glossogobius giurus*; *campa, Rhyacichthys aspro;* and *paliling, Sicyoptrus lachrymosus.* Previously, Blanco (*op. cit.*) reported on the breeding habits and embryology of *Mirogobius lacustris* Herre.

Yosie Dotu (1957 C) described the life history of three species of Japanese gobies. He stated that *Odontamblyopus rubicundus* seemed to grow to 180 mm. in total length in a year and some individuals became mature in a year. *Luciogobius guttatus,* a smaller species, attained maturity after a year at 33 mm. T. L. in both sexes (Dotu, 1957 b); *Gobius lidwilli* grew to 17–20 mm. in T. L. for females and 16–19 mm. for males and became mature (Dotu, 1957 a). Dotu and Mito (1955) reported that *Sicydium japonicum* attained sexual maturity at 70 mm. in about 2 years.

OBJECTS OF THE STUDY

The objects of the present work are (*a*) to determine the average size of *Glossogobius giurus* at sexual maturity; (*b*) to determine the possible age of the fish at sexual maturity; and (*c*) to recommend regulatory measures aimed towards the conservation of this important fish species of Laguna de Bay, based on results obtained from (*a*) and (*b*).

Because of the fact that depletion of the fisheries of Laguna de Bay, especially that of the *biyang puti,* seems to be continuing in spite of the efforts of the government to rehabilitate the lake, it may be postulated that the *biyang puti* may be an exception to the rule that an increase in size and age will necessarily lead to an increase in sexual maturity, leading to more fish in the lake. Most probably, the majority of the fishes caught were immature and were not given a chance to breed or perhaps, many of those caught were already mature and were

about to spawn but were deprived of the opportunity to do so.

Inasmuch as the species of fish that are cannibalistic which devour their young reduces the number that attain maturity, the *biyang puti* may be considered such a type of cannibalistic fish, judging from its slow increase in number in the lake.

GENERAL DESCRIPTION OF THE SPECIES

The *biyang puti*, white goby, is one of the largest of the family *Gobiidae*. It thrives in rivers, lakes, and the sea from the Philippines and East Indies, North to China, East to Polynesia, West to India and the east cost of Africa (Herre, 1953). But although it is of wide distribution, still it is not considered of direct importance in most countries. However, it is one of the six species that contribute to the commercial importance of *ipon* (goby fry) fisheries of the Philippines. Herre (1927) described this species as follows:

"Dorsal, VI, 1–9. 8; there are 30–32 scales in a longitudinal series, 9 or 10 in a transverse series; and 21–26 before the first dorsal.

The elongate slender body laterally compressed, with a deep flat caudal peduncle and a very large, wide, and long head which is contained from 2.8 to 3.3 times in length; the greatest depth from 5.2 to 5.6 times in length; the eyes partly superior and rather small, less than an eye diameter apart, their length, 6 to 8 times in head and 2.5 to more than 3 times in snout, which is 3 or a little more or less than 3 times in head; the distance from tip of snout to posterior margin of eye less than postorbital length of head; the dorsal profile descends uniformly from first dorsal to the tip of the smooth, convex snout; the oblique mouth, large with projecting lower jaw; the maxillary extends backward as far as a point below front of eye or even front margin of pupil; in both jaws, the outer row of teeth is fixed, large, strong, and canine-like; then follow several rows of fine, sharp, depressible teeth, the innermost one, much larger than the others; at the sides, these disappear, leaving only the outer and inner rows of large teeth; the scales on nape, smaller than those of trunk; the head naked except for 3 or 4 rows of smaller scales on upper part of opercle; 4 to 5 parallel longitudinal seams or lines of very fine papillae on preopercle; the ventrals are very large and form an admirable sucking disk; the pectorals are large and extend posteriorly beyond ventrals; the vertical fins, of moderate size; the caudal, large, the length, nearly equal that of the head.

The ground color in life varies from pale fawn or buff to yellowish, with a more or less, golden glint on sides; there are 5 large dark to black spots on sides, the last at base of caudal; alternating with them are 5 short, broad, dorsal crossbars of similar color, the first one, above the opercles, the second, including base of first dorsal; the head may be pale but usually varies from brownish to black, with 4 or 5 pale longitudinal lines on cheeks; usually a brown bar extends from lip upward to eye and another one from eye, diagonally across cheek; there are 2 dark brown or blackish longitudinal bars on basal part of pectoral in a pale or golden brown color; the dorsals and caudal crossbarred by dark bands or rows of dark spots, those on first dorsal, but little developed, those on caudal, stopping before lower margin is reached; the pectorals and anal, clear; the ventrals, dusky with a broad clear margin; the eyes, blue. During the breeding season, at least, the anal papillae become orange."

The *biyang puti* is a bottom dweller, spending most of its life in fresh-water. Manacop, *op. cit.*, states that *Sicyopterus extraneus* spawns in fresh-water and this condition is probably true for the *biyang puti*. This phase of the biology of the fish was not investigated. As yet, very little is known of the biology of the different species of gobies.

METHODS AND MATERIALS OF STUDY

SURVEY OF THE NATURAL HABITAT

A field trip to Cardona, Rizal, was made on September 14, 1958. In that field trip, it was observed that at this area, Laguna de Bay was studded with some small islands, not far from the shores. Water hyacinths, *Eichornia crassipes* were also observed to be growing luxuriantly, floating especially near the fish corrals. The lake bottom was found to be of a muddy nature. An interview with five fishermen revealed that *biyang puti* could be found at any portion of the lake in the area.

Another field trip was made at Taguig, Rizal, on December 1, 1958, primarily to find out through an interview with a fisherman, the fishing gear used in the catching of *biyang puti* in that town. Again it was observed that *seket* was the gear generally used.

TIME AND PLACE OF STUDY

The sampling was made from August, 1958 to August, 1959. Field observations were made in the towns of Cardona and

Taguig, Rizal, the main landing area for this fish. Information about the fishery of Laguna de Bay was secured from fishermen from both towns. Fish samples, secured from known suppliers from Cardona and Taguig, were landed at Sta. Ana market, Manila. Laboratory examinations of the samples were carried on at the Entomology and Virus Laboratories of the Bureau of Plant Industry and the Biological Research Center Laboratory, National Institute of Science and Technology, Manila.

The data gathered for the determination of age and size at sexual maturity of *biyang puti* were limited for a period of one year. Originally, it was planned to get weekly samples of different sizes of fish in order to observe the length frequency distribution, maturity stages of the eggs, and the stomach contents, but because this investigation was done during the period when restrictions on fishing activities were initiated by the government in its efforts to rehabilitate the fisheries of Laguna de Bay, the original plan had to be modified. A sample of the species of fish under study was taken at least twice a month, inasmuch as a very limited supply only of *biyang puti* could be found in the local markets.

QUANTITY AND SIZE OF WHITE GOBY SOLD IN THE MANILA FISH MARKETS

Perusal of the Fisheries Statistics of the Philippines for 1959 showed that the annual production of commercial fishing vessels for goby has been nil since 1955, so that only the record for the year 1957 was represented, amounting to 30,870 kilograms for the entire country. The record must have been a poor representation of the fact for the amount is insignificant even for the landings of Laguna de Bay alone.

A monthly summary of *biyang puti* handled in the Manila markets for the years 1958 and 1959 was instituted and is shown in Figure 1. The fish recorded in this figure are those most probably caught from Laguna de Bay, inasmuch as a survey of the most important Manila markets showed that the gobies sold were those caught along the municipalities of Biñan, Sta. Rosa, Muntinlupa, Pasig, Taguig, Cardona and Binañgonan. For the year 1958, January, February, March, August, September, October, November and December seemed to be the months when the catch was highest; and for 1959, March to July seemed to be the months of highest catch.

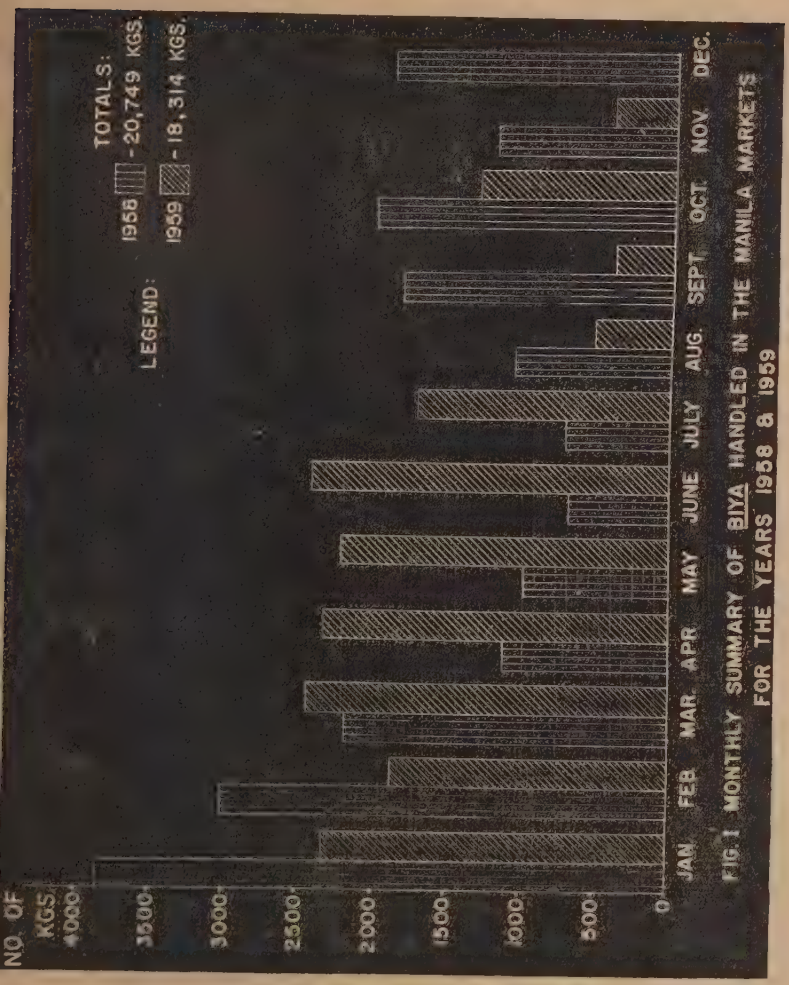


FIG. 1 MONTHLY SUMMARY OF BIYA HANDLED IN THE MANILA MARKETS FOR THE YEARS 1958 & 1959

The survey also showed that the *biyang puti* caught during the year 1958–1959 were very small, most of them about 40 to 130 millimeters in standard length (Plate 2, fig. 1). Specimens examined in this study ranged from 50 to 242 millimeters in standard length and were bought from a known fish dealer at the Sta. Ana Public Market, Manila (Plate 2, figs. 2 & 3).

In each sample, the standard lengths of all fish of both sexes were measured and recorded to the nearest millimeter.

For record purposes and later studies in correlation, the total length, width and depth of each fish at the region of the pectorals were also taken. However, in this study, the standard length is the measurement always referred to.

An analysis of length frequencies of 3,768 specimens of *biyang puti* was made. The so-called frequency method or Petersen method consists of a study of the progression modes in length frequency distributions in relation to time. Since the number of fish measured each month was not constant, the length frequency distributions were made comparable by converting the frequencies into percentages of total for each month. The examination of scales and other bony parts as practiced in temperate countries in determining age could not be used because in a tropical country like ours, such methods are not practical, inasmuch as the rings of growth in the bony parts could not be easily discerned with the absence of the four distinct seasons of the year, which are responsible for the appearance of the rings of growth.

DETERMINATION OF THE AGE

The length frequency method is also the method used to estimate the age of the fish studied. Inspection of the frequency polygons revealed that almost all of them showed the presence of at least two modes. These modes indicate the average lengths of the age groups to which the samples belong.

Together with the determination of the age was the determination of the size at first maturity of the species. To do this, the ovaries of 1,019 female specimens preserved in 5 percent formalin were examined and the condition of maturity ascertained. The presence of maturing and mature or ripe eggs was used as a criterion to determine the sexual maturity of the fish and, more or less, the spawning season. A scalpel was used to remove the pair of ovaries from each female. To determine the stage of maturity, a portion of the ovarian tissue was teased on a slide to separate the eggs; a drop or two of water were added to the material which was then covered with a cover glass and examined under a binocular stereoscopic microscope.

In addition, the diameters of 3,233 ova from female specimens caught from the towns of Taguig and Cardona were

measured for determining the different stages of maturity. This was done with an eyepiece micrometer with a value of 15.8 micra (.0158 mm.) for each micrometer unit. The egg was measured at its longest diameter and recorded.

EXAMINATION OF THE STOMACH CONTENTS

To study the stomach contents of *biyang puti,* 161 specimens of both sexes were taken at random from the Cardona samples for a period of six months. The standard length of the specimens so examined ranges from 85 to 239 millimeters. Each specimen was dissected for its gut, and its contents examined with a microscope, two or three times. In the absence of a counting cell, the frequency of occurrence was used as a quantitative index. This method consists of recording the presence or absence of a given food item and is the easiest way of analyzing the stomach contents. Furthermore, the wide variety of foods and their small volumes made it most preferable to use the frequency-of-occurrence method.

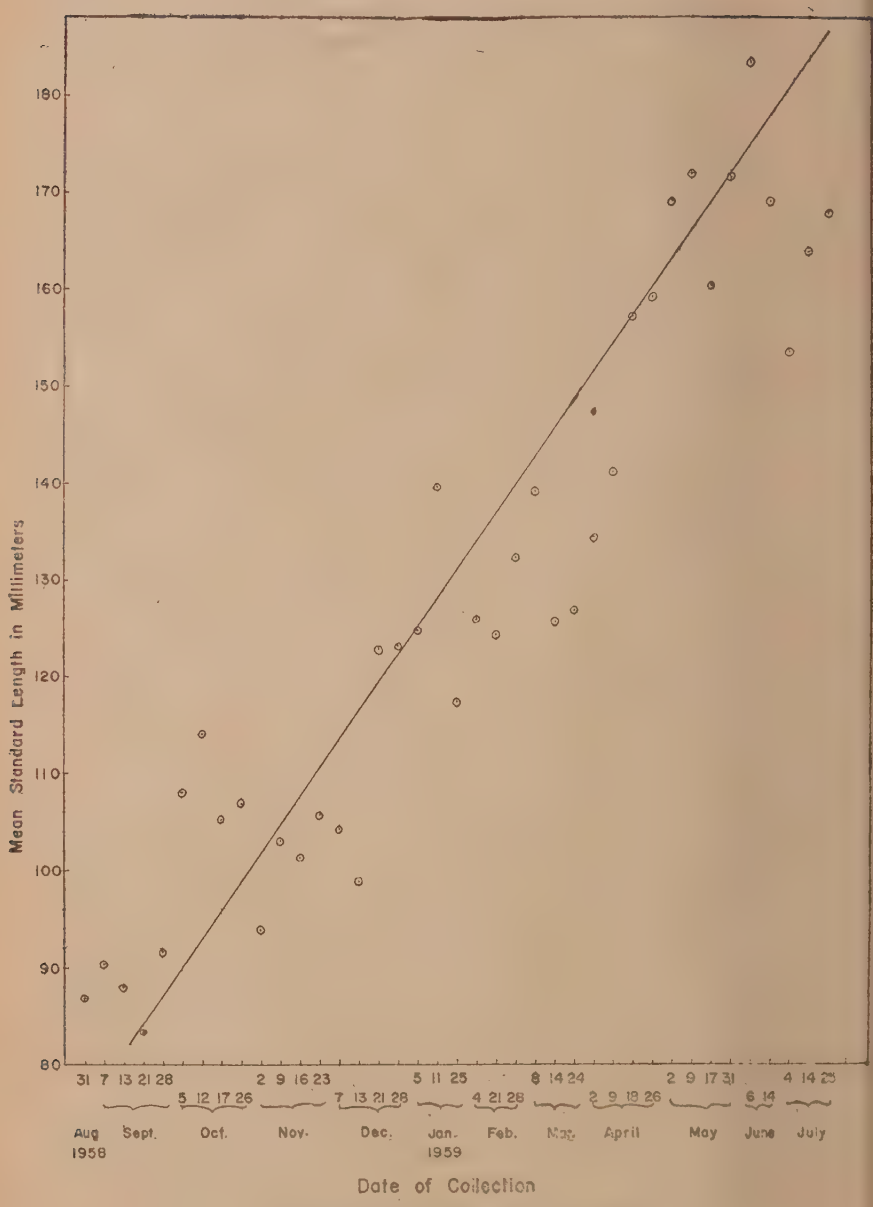
The seasonal changes in the food of *biyang puti* could not be shown here for lack of sufficient data. It is unfortunate to mention the fact that due to some unavoidable reasons the examination of the gut contents the whole year round could not be made.

DISCUSSIONS

The Quantity of "Biyang Puti" Sold in the Manila Fish Markets

From the survey of the quantity of *biyang puti* landed and sold in the Manila fish markets, it can be seen that there was a decrease in the catch of *biyang puti* in Laguna de Bay (Fig. 1).

It is also shown that the quantity of *biyang puti* handled in the Manila markets is lower in 1959 than in 1958. This can be explained by the fact that a ban on the catching of this fish by means of *seket* and *pukot* from January 1 to December 31, 1959, was put in effect in Laguna de Bay, under Fisheries Administrative Order No. 3–6, dated October 13, 1958. It is interesting to note, however, that even with the existence of the ban then, the decrease in the quantity of fish handled in the city of Manila in 1959 was not significant. This may also be a reflection of the government's inability to enforce the prohibition governing the catching of this fish.



MEAN STANDARD LENGTHS OF 30 WEEKLY SAMPLES OF BIYANG PUTI FROM TAGUIG AND CARDONA, RIZAL

TABLE I

LENGTH-FREQUENCY DISTRIBUTION OF *G. BIURUS* COLLECTED FROM TAGUIG AND CARDONA, RIZAL FROM 1958-1959

WEEKLY SAMPLE MEANS OF STANDARD LENGTHS INDICATING PRONOUNCED BREEDING SEASON

The weekly sample means of all samples were taken and graphically represented in Figure 2, as based on Table II. It may be noted therefrom that more small fish are caught during the months of August and September, the mean size of the fish increasing as the year progresses, indicating that although this species breeds throughout the year, yet there is more of

TABLE II.—*Mean standard lengths of weekly samples of biyang puti.*

Date	Mean standard length in Mm.	Date	Mean standard length in Mm.
1958		1959	
August 31	86.7	January 5	124.8
September 7	90.3	January 11	139.1
September 13	88.1	January 25	117.5
September 21	83.1	February 4	126.5
September 28	91.7	February 21	124.4
October 5	107.9	February 28	132.7
October 12	114.0	March 8	139.7
October 19	105.1	March 14	125.5
October 26	106.6	March 24	126.3
November 2	93.8	April 2	134.1
November 9	103.0	April 9	141.0
November 16	101.2	April 18	157.1
November 23	105.8	April 26	159.2
December 7	104.2	May 2	169.5
December 13	98.7	May 9	172.7
December 21	122.8	May 17	160.5
December 28	123.3	May 31	171.2
		June 6	183.6
		June 14	169.3
		July 4	153.1
		July 14	164.0
		July 25	168.0

the smaller fish caught during the onset of the rainy season. Although a ban was imposed in January 1959, yet the increasing mean standard length indicates a progressive increase in the size of fish in the lake, and it appears that the breeding season is more pronounced during the rainy season (June to August) as is logical and found to be true in other freshwater fishes.

SIZE AND AGE AT FIRST MATURITY

The length frequency distributions of all the specimens examined are shown in Table I and graphically represented in Figure 3. The length frequency distributions of total monthly samples are indicated in Figure 4. These curves were smoothed out by a moving average of three. The

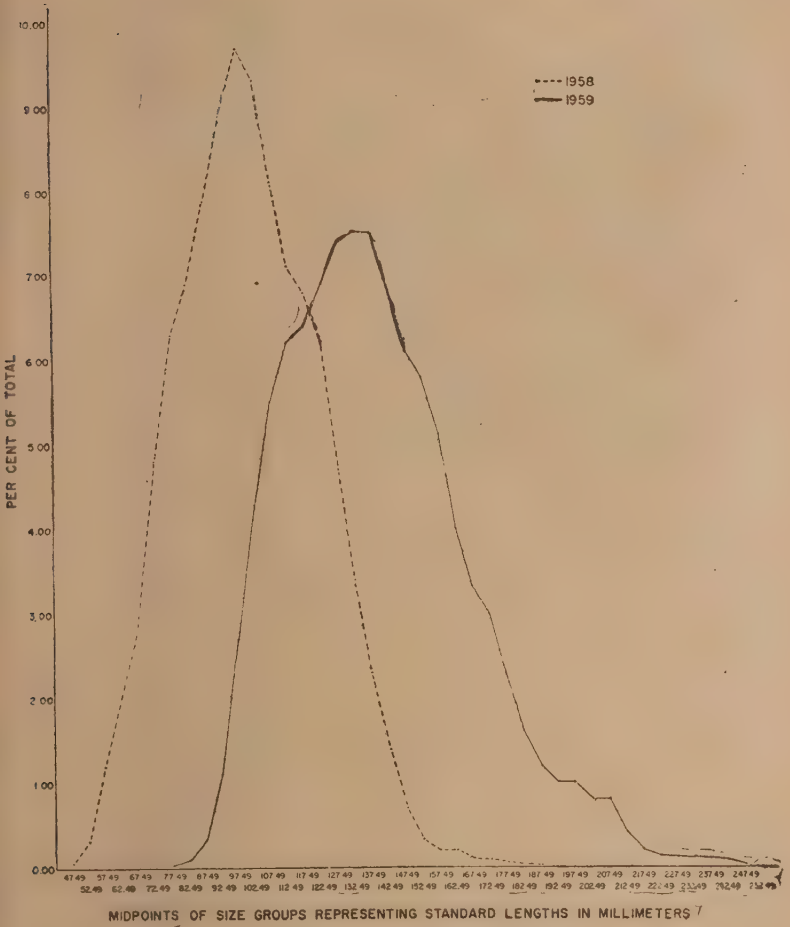


FIG. 3 – YEARLY LENGTH FREQUENCY DISTRIBUTIONS, EXPRESSED IN PERCENTAGE, OF WHITE GOBIES FROM TAGUIG AND CARDONA, RIZAL

length frequency method by Petersen was used here to determine the dominant size groups of the population under study. According to this method, the aggregate fish lengths fluctuate around certain modes, which represent dominant size groups.

Examination of the growth curves in Figure 4 shows the presence of at least two modes in almost all monthly samples collected. The first mode (A) appearing in August, 1958 and represented by size range 75–79.9 mm. was still abundant in

January, 1959 with the size range 125–129.9 mm. This gives a difference of 8 mm. per month which may indicate the monthly growth rate. The second mode (B) in August, 1958 may have represented fish available in September and October and became insignificant thereafter. The mode (C) in September, 1958 with size range 70–74.9 mm. represents a strong size group, forming the predominant catch from November, 1958 to February, 1959, having then shifted to 125–129.9 mm. The difference of 9 mm. may indicate the monthly increment in growth. This size group still formed the bulk of the fishery up to June, 1959.

A size group (D) (105–109.9 mm.) which first became available in February, 1959 constituted the dominant catch from March to April, 1959 and was in the fishery until July, 1959, with its size range having moved to 170–174.9 mm. This gives an average size increment of almost 11 mm. per month.

A new peak (E) just appearing in March with size range 105–109.9 mm. did not become predominant in the fishery until July, 1959 after it had shifted to 150–154.9 mm., although it was available to a limited extent during the intervening months.

Taking into consideration the findings in this investigation that *biyang puti* spawns every month after attaining sexual maturity, and assuming that they grow about 9.3 mm. per month, then the age group with a modal length of 75–79.9 mm. would probably be one year old fish (Age O) in August 1958, having been born sometime in November or December, 1957. It follows that specimens of the Age O group should be about 110–114.9 mm. long upon completing their twelfth month of life.

After February, 1959, specimens below 75 mm. could no longer be collected as a result of the ban on the use of *sakot* and *pukot* from January 1, 1959, and the sampling must have been biased with the catching of predominantly large-sized fish by the use of larger-mesh gear. Nevertheless, the samples collected during this period helped to assess the real condition of the fishery. Since other fishing gears were used, the goby catch consisted mainly of larger and therefore older specimens, ranging from 75 to 249.9 mm. with a modal length of 130–134.9 mm. (Fig. 3). This goes to show that

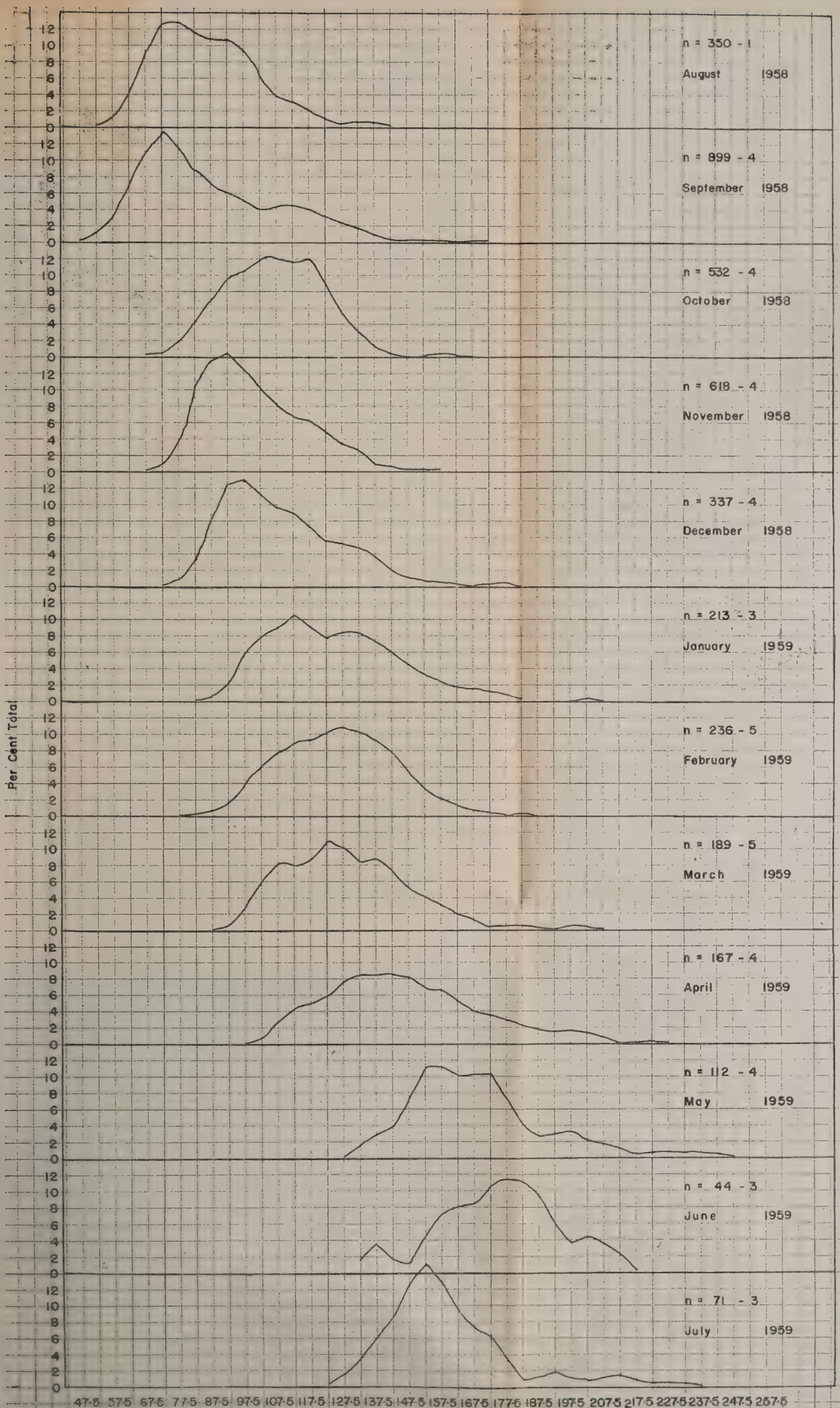


FIGURE 4

MONTHLY LENGTH FREQUENCY DISTRIBUTIONS, EXPRESSED IN PERCENTAGE, OF BIYANG PUTI FROM TAGUIG AND CARDONA, RIZAL

if selective gears were used for *biyang puti,* the fishing pressure would be readily eased and this will allow the fish to grow more and to breed at least once before they become available to such gear and are captured.

Assuming the presence of three age groups of *biyang puti* collected for this study, the approximate age groups with the following modal lengths are:

?–114.9 mm.	1st year (Age 0)
115–224.9 mm.	2nd year (Age I)
225– ? mm.	3rd year (Age II)

Among the specimens from Taguig, the smallest female fish found to be mature was 66 mm. long while among the specimens from Cardona, the smallest was 71 mm. From the above calculation, it can be inferred that these fish were in their first year of life (Age 0). However, the majority of the females matured when they were mostly 105–114.9 mm. long. Hence, at first maturity, this species on the average measures from 105–114.9 mm. or when the fish is at the end of its first year of life (Age 0).

SIZE OF EGGS AT DIFFERENT STAGES OF MATURITY

Most of the fish examined for the age and length frequency were discarded after they were measured, but most of the female specimens were later examined for sexual maturity and were preserved in 5 per cent formalin solution.

The Table for Maturity stages described in Buckmann (1929) was followed with suitable modifications. A brief description of the eggs for each stage follows:

Stage I: Juvenile—Eggs are very tiny and closely attached to each other by the connective tissue of the ovary, glassy transparent, more or less, rounded in shape.

Stage II: Quiet—The eggs occur singly and seen as transparent cells, each with a distinct nucleus. They are ovoid or elliptical in shape. Some are pear-shaped. Juvenile eggs are found together with the ova of this stage.

Stage III: Preparation—Eggs are single but are bigger in size, being twice or thrice longer than their width if elongated; others remain ovoid. They appear yellowish to grayish because they have become yolked.

Stage IV: Fusing or pressing together—Eggs become elongated or club-shaped. They appear dark and therefore opaque for they are totally yolked. They are crowded to each other.

Stage V: Stretching—Eggs are much bigger than in Stage IV and their shape tends to remain club-like; others become comma-like. The yolk in separate globules is opaque and fills the egg; some eggs are translucent.

Stage VI: Mature—The eggs are glassy transparent, with some regions remaining translucent as under V. Some are club-shaped, or comma-like and still others are elongated. The oil globules are not numerous for they appear to coalesce.

As found in other fishes, although the ova have been classified into definite stages, yet most of the ovaries examined cannot fall strictly under one stage category since eggs of different stages have been almost found together in one ovary. In most cases, two or more succeeding stages are always found together. It is this characteristic which also occurs in other species of fish that may explain the monthly spawning of this species throughout the year, a phenomenon known as expanded spawning habits. A rough classification of the ovaries examined was made by grouping them into four categories (immature, maturing, mature and spent), based on

TABLE III.—*Stages of the ovaries and corresponding egg diameters and the number of ovaries of female biyang puti collected from Taguig and Cardona, Rizal from September 1958 to August 1959*

Month and year	Condition of ovaries and diameters of eggs in mm.						Total examined	Percentage mature
	Immature		Maturing		Mature		Spent	
	I	II	III	IV	V	VI	VII	
	0.01 to 0.03	0.05 to 0.13	0.12 to 0.26	0.21 to 0.48	0.30 to 0.83	0.55 to 0.83		
1958								
September	11		22		1			34	2.94
October	63		45		7			115	6.08
November	103		59		20		3	185	10.80
December	105		41		24		2	175	13.71
1959								
January	56		23		27			106	25.47
February	52		33		26			111	23.42
March	58		26		16		1	101	15.84
April	41		8		32		1	82	39.04
May	21		14		13		1	49	26.56
June	4		2		8			14	57.13
July	4		5		14			23	60.83
August	8		5		11			24	45.82
					199		8	1,019	32.15

TABLE IV.—*Monthly percentages of the different maturity stages of ovaries of biyang puti examined from September 1958 to August 1959.*

Month and year	Percentage				Total ovaries examined
	Immature	Maturing	Mature	Spent	
1958					
September	32.35	64.71	2.94	-------	34
October	54.78	39.13	6.08	-------	115
November	55.67	31.89	10.08	1.06	185
December	60.00	25.14	13.71	1.14	175
1959					
January	52.83	21.69	25.47	-------	106
February	46.85	29.72	23.42	-------	111
March	57.42	25.74	15.84	0.99	101
April	50.00	9.75	39.02	1.21	82
May	42.85	28.57	26.53	2.04	49
June	28.57	14.28	57.14	-------	14
July	17.39	21.73	60.86	-------	23
August	33.33	20.83	45.83	-------	24
GRAND TOTAL	-------	-------	-------	-------	1,049

the egg diameter of the most dominant stage present in the ovaries examined. The ovaries containing eggs of stages I and II are considered immature; the ovaries with eggs in stages III and IV, maturing; the ovaries with eggs in Stages V and VI, mature; and, the ovaries with loose walls and traces of ripe eggs, spent. (Tables III and IV and Plate 3).

To get the average size of the eggs of the different stages, the diameter of 3,233 eggs from female specimens was measured and averaged for a period of one year.

The size ranges of the different stages are:

Immature
- Stage I—Frequencies with a range between 0.1 and 0.03 mm.
- Stage II—Frequencies with a range between 0.05 and 0.13 mm.

Maturing
- Stage III—Frequencies with a range between 0.12 and 0.26 mm.
- Stage IV—Frequencies with a range between 0.21 and 0.48 mm.

Mature
- Stage V—Frequencies with a range between 0.03 and 0.83 mm.

The eggs that are individually discernible to the naked eye are already mature and belong to stages V and VI, with a size ranging from 0.30 to 0.83 mm.

Although the study of the maturity stages of the male *biyang puti* was not conducted in great detail, gross examination of males corresponding size ranges done during sex determination of the fish showed that there is a close correlation with the maturity stages of corresponding female size groups.

FREQUENCY OF SPAWNING

From Table IV, it can be seen that during the months covered by the study, all collections of *biyang puti* indicate a high percentage of immature fish. However, maturing and mature fish are found during most months of the year, a strong evidence that spawning takes place continuously. A similar phenomenon was also found in the goby *Sicyopterus extraneous* by Manacop (*op. cit.*). Figure 5, a graphical representation of Table IV, shows very clearly the different conditions of the ovaries as they were seen during each month from September, 1958 to August 1959. It can be noted that the six-month period from September, 1958 to February, 1959 is characterized by ovaries with a small percentage of mature eggs, the immature and maturing eggs being more dominant. On the other hand, the period from June to August, 1959 is characterized by ovaries with a greater percentage of mature eggs and these months may be considered as the peak of spawning of the species during the year.

FOOD HABITS

Table V gives the percentage frequencies of occurrence of food in different size groups of 161 *biyang puti* taken from Cardona, Rizal, from January to June, 1959. The food items shown here are mainly prouped into three, namely: plants, animals, and unidentified miscellaneous items. Of these three, the plants are the most relished as evidenced by the wide variety of forms represented. Of the blue-green algae, *Microcystis* is most relished. It is absent in only one size group and in most cases the frequency of occurrence is 100%. Of the green algae, *Chlorella* and *Protoderma* are most commonly found in the collection of gut contents. *Chlorella* occurs in 25% to 100% of the stomachs examined and is represented in almost all size groups while *Protoderma* is used as food by practically all size groups in 18% to 100%. This is not as common as *Chlorella*. The diatoms were also found in the stomachs of this species. *Diatoma* is the most relished among fish of intermediate size groups. *Meridion* comes next; species of the other representative genera of Chrysophyta were used as food only by a limited few. The euglenophytes are represented by only three genera in few size ranges and also to a very limited extent. Two kinds of bacteria are relished—the *Bacillus* and the *Coccus* types, which when found in the

TABLE V.—*Percentage Frequencies of Occurrence of Food in Different Size Groups of Biyang Puti Taken from Cardona, Rizal Farm, January to June 1959*

Food item	Standard lengths and numbers of stomachs containing food																												
	85–89.9	90–94.9	95–99.9	100–104.9	105–109.9	110–114.9	115–119.9	120–124.9	125–129.9	130–134.9	135–139.9	140–144.9	145–149.9	150–154.9	155–159.9	160–164.9	165–169.9	170–174.9	175–179.9	180–184.9	185–189.9	190–194.9	195–199.9	200–204.9	205–209.9	220–224.9	225–229.9	230–234.9	235–239.9
	1	4	5	7	8	10	11	9	7	9	12	9	9	10	9	8	5	3	4	5	3	3	1	3	1	2	1	1	1
Plants:																													
Cyanophyta—																													
Microcystis	100	75.0	60.0	85.7	100	80.0	63.6	66.6	100	100	100	100	100	100	100	100	100	100	100	100	100	66.6	100	100	100	100	100	100	100
Anabaena	100				37.5	50.0	45.4						11.1								20.0								
Gloeocapsa														22.8															
Aphanocapsa																						33.3	100	33.3	100		100		
Clathrocystis									17.3																				
Chlorophyta—																													
Binuclearia												22.2	22.2																
Chlorella	100	33.3	60.0		100	33.3	66.6	55.5	57.1	55.5	66.6	44.4	33.3	80.0	66.6	37.5	80.0		25.0	80.0	100		100	33.3	100			100	100
Chlorococcum		25.0	40.0		62.5	50.0	45.4	71.4			25.0	22.2	22.2	20.0	22.2		20.0	66.6	100		100	33.3		33.3		50.0			
Chroococcus							45.4			33.3					33.3												100		
Closterium				42.8																									
Coelastrum								22.2			16.6	22.2	22.2	40.0	55.5		40.0		75.0										
Cosmarium		25.0		42.8																									
Gloeocystis	100	75.0		57.1	75.0	50.0		44.4	42.8	22.2	25.0		33.3	80.0	77.7	37.5	20.0		50.0	20.0				33.3					
Hormidium							18.2																						
Oocystis			40.0	42.8				11.1	28.6										25.0										
Pandorina							36.2		28.6																				
Planktosphaeria										22.2																			
Protoderma		75.0		57.1	37.5		18.2	33.3		55.5	16.6	44.4	33.3	40.0	22.2	25.0	40.0		75.0	80.0	66.6	100	100	33.3	100	50.0	100	100	100
Scenedesmus			40.0																										
Sphaerocystis						50.0	45.4						22.2											33.3					100
Stichococcus	100		40.0				36.4				33.3	22.2	22.2					33.3			66.6	66.6	100	33.3					

Food item	Standard lengths and numbers of stomachs containing food																												
	85–89.9	90–94.9	95–99.9	100–104.9	105–109.9	110–114.9	115–119.9	120–124.9	125–129.9	130–134.9	135–139.9	140–144.9	145–149.7	150–154.9	155–159.9	160–164.9	165–169.9	170–174.9	175–179.9	180–184.9	185–189.9	190–194.9	195–199.9	200–204.9	205–209.9	220–224.9	225–229.9	230–234.9	235–239.9
	1	4	5	7	8	10	11	9	7	9	12	9	9	10	9	8	5	3	4	5	3	3	1	3	2	1	1	1	1
Chrysophyta—																													
Achnantes						50.0				22.2				40.0															
Cyclotella	100	25.0										11.1																	
Diatoma		75.0						44.4	42.8	55.5	58.3	88.8	33.3	40.0	100	87.5	80.0	66.6	50.0	80.0		33.3	100	66.6		50.0	100		
Fragilaria			40.0							22.2																			
Mastogloia																													
Meridion		75.0	40.0	14.5	37.5		45.4		28.6	55.5	33.3	44.4	33.3	40.0	33.3					40.0	66.6	66.6	100						
Nitzschia														20.0															
Stauroneis								33.3																					
Synedra											83.3	22.2	22.2				20.0												
Tabellaria					37.5																								
Euglenophyta—																													
Chlamydomonas								33.3								12.5													
Chlamydomonas (Resting stage)																						33.3							
Euglena												11.1		20.0															
Trachelomonas	100	25.0																											
Schizomycetes—																													
Bacillus bacteria	100	25.0	80.0	85.7	62.5	70.0		66.6	57.1	77.7	66.6	55.5	44.4	70.0	77.7	37.5	60.0	66.6	25.0		66.6			33.3		50.0			100
Coccus bacteria					42.8	50.0	45.4	33.3	57.1	55.5	50.0	44.4	44.4	60.0	33.3	62.5	60.0		25.5		66.6			33.3		50.0			100
Higher plants fibers (unidentified)									28.6													100							

Food item	Standard lengths and numbers of stomachs containing food																												
	85–89.9	90–94.9	95–99.9	100–104.9	105–109.9	110–114.9	115–119.9	120–124.9	125–129.9	130–134.9	135–139.9	140–144.9	145–149.9	150–154.9	155–159.9	160–164.9	165–169.9	170–174.9	175–179.9	180–184.9	185–189.9	190–194.9	195–199.9	200–204.9	205–209.9	220–224.9	225–229.9	230–234.9	235–239.9
	1	4	5	7	8	10	11	9	7	9	12	9	9	10	9	8	5	3	4	5	3	3	1	3	1	2	1	1	1
Animals:																													
Protozoa—																													
Colpps							36.4				16.6																		
Opalina											8.3																		
Peritrichida								22.2	28.6				22.2			12.5													
Stentor						50.0							22.2																
Unidentified ciliates				42.8							16.6			20.0		25.0													
Rotifera					47.5																								
Crustacea *Cypris*			40.0			50.0																							
G. gaurus Whole								44.4	14.3		41.7				44.4			33.3	40.0	33.3									
Remains		25.0		57.1	75.0	50.0	100	44.4	57.1	55.5		44.4		40.0	33.3	60.0	20.0	66.6	25.0	60.0	33.3	100	33.3		50.0	100		
Sponge spicules		25.0	40.0	42.2	62.5	50.0		11.1		77.7	16.6	22.2	22.2	60.0				66.6	25.0	80.0	33.3								
Unidentified																													
Miscellaneous																													
Unidentified food remains										22.2																			
Unidentified elongated cells										22.2																			

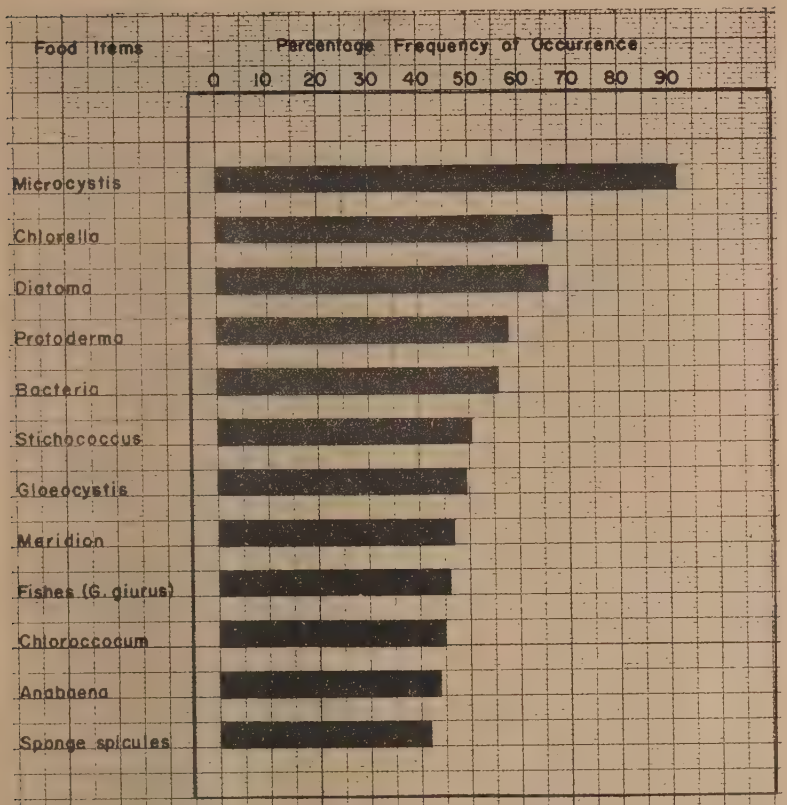


FIGURE 6

FREQUENCY OF OCCURRENCE OF THE MOST COMMON FOOD ITEMS OF 161 BIYANG PUTI

stomachs of the *biyang puti,* are never below 25% in percentage of occurence. Higher plants appear in the form of fibers which could not be identified due to the advanced state of decomposition.

The animal group includes representatives of Protozoa, Porifera, Rotifera, Crustacea, and fishes. The remains of fishes and the spicules of fresh water sponges are most commonly

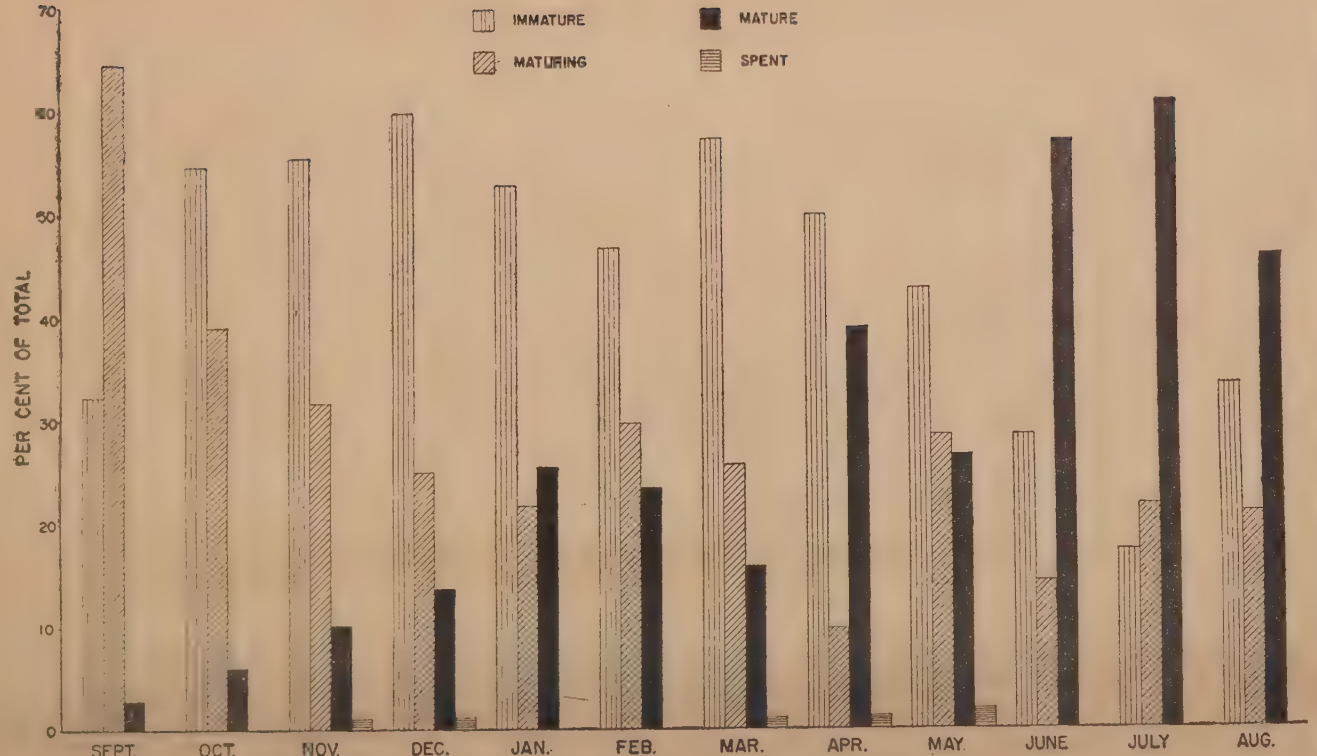


Fig. 5. Condition of ovaries of Biyang Puti from Taguig and Cardona, Rizal, from September, 1958 through August, 1959.

found. Remains of fishes occur in not less than 20% and sponge spicules, in not less than 10%.

A noteworthy interpretation that can be made here is the presence of either the whole body or remains of fishes. For the identification of the species, it is not difficult if the whole body is seen as in the seven size groups appearing in Table V. But in the case of those where only the remains in the form of scales and fins are found, it is difficult to identify the species. However, in this study, it can be assumed that the majority of those taken in belong to *G. giurus* since the whole bodies of fish found in the stomach were all of this particular species. Furthermore, several gobies that were measured for their standard lengths showed the presence of whole small gobies in their buccal cavities. Another evidence in favor of the assumption is the presence of ctenoid scales, which are exactly the type found in *biyang puti.* Thus, it can be assumed further that this species is cannibalistic because it preys upon its own kind.

The utilization of *Microcystis* as food by the *biyang puti* in Laguna Lake is of great importance from the point of view of public health, for the *biyang puti* help greatly in controlling foul odors that are formed by "blooms" of *Microystis* during summer.

The unidentified miscellaneous items which consist of detritus occurred only in one size group that range from 135–139.9 mm. indicating that the fish is not a detritus feeder.

It will be noted that the food preference of the *biyang puti* is for vegetation rather than for animals and other miscellaneous food items. This is clearly seen in Figure 6 which is a graphical representation of the most common food items taken in by *biyang puti.* It will also be noted that there is no significant variation in the kind of food items taken in by the different size groups.

In this fish, the occurrence of an unidentified fluke found in almost all size ranges of the fish examined is a case of parasitism. The occurrence in the stomach of any size group is never lower than 21%. It may be assumed that *biyang puti* is a host of the fluke since it is found, not only in the stomachs, but also in the walls of a few ovaries. This will be studied in the future.

SUMMARY AND CONCLUSIONS

The depletion of Laguna de Bay has been observed for a long time and since 1950, the commercial catches showed de-

finite and conclusive sign of depletion. But to be able to take the correct steps for its rehabilitation, a biological understanding of the different species inhabiting the lake is necessary. One of the fish species found in the lake is the *biyang puti, Glossogobius giurus,* an important source of protein to the people living along its shores for which the present study was devoted.

Fish collected from Cardona and Taguig, Rizal, amounting to 3,768 specimens of *biyang puti* were bought from the Sta. Ana Market so as to determine their age and size at sexual maturity. These were estimated with the use of the length-frequency method. To ascertain the sexual maturity of the species, gross microscopic examinations of 1,019 ovaries and measurement of the ovarian eggs were carried on. The food preference of 161 white gobies was also studied by examination of their stomach contents, using the frequency-of-occurrence of food items as a quantitative index.

The following important findings may be drawn from the results of this study:

1. On the average, *G. giurus* matures at size range 105–114.9 mm. or at the time when the fish is at the end of its first year of life (Age 0).
2. Eggs that are about to be spawned measure from 0.55 to 0.83 mm. in diameter.
3. Spawning takes place at monthly intervals as evidenced by the presence of usually three succeeding stages of eggs in sexually matured females.
4. *Microcystis* is the blue-green algae most utilized as food while *Protoderma* and *Chlorella* are the green algae most preferred. *Diatoma* and *Meridion* are the diatoms most frequently taken in.
5. While predominantly dependent on algae, *biyang puti* are also piscivorous and carnivorous, preying on their own kind.
6. An unidentified fluke has also been found associated with this species of fish, which is worth studying.

RECOMMENDATIONS

Based on the findings in this study, the following may be recommended for the conservation and, or rehabilitation of the *biyang puti, Glossogobius giurus* fishery of Laguna de Bay:

1. The catching of white gobies measuring less than 135 millimeters by any kind of fishing gear must be prohibited.

The use of *seket* and *kaladkad pambiya* must be banned completely, or at least, the mesh size opening (30 mm. mesh stretched), which is the size specified for experimental purposes for the impounding section of the net of a *seket*, must be enforced by law or Administrative Order to permit the easy passage or escape of the young and immature individuals, thereby providing enough spawning *biya* to spawn at least only once.

2. The peaks of the spawning season, the months of June, July and August, must be designated closed season periods and the provisions of Fisheries Administrative Order No. 35, dated June 4, 1953, entitled "Regulation of the *Kaladkad Pambiya* and the conservation of *Biyang Puti* in Laguna de Bay and its tributaries" must likewise be rigidly enforced.

3. The stocking of Laguna de Bay with the young of *biyang puti* should be made a regular project of the Bureau of Fisheries and other entities of the Government, charged with regulatory and law enforcement functions and responsibilities.

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For all of them God's choicest blessings are implored.

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ILLUSTRATIONS

TEXT FIGURES

1. Monthly Summary of *Biyang Puti* Handled in the Manila Markets for the Years 1958 and 1959
2. Mean Standard Lengths of 39 Weekly Samples of *Biyang Puti* from Taguig and Cardona, Rizal
3. Yearly Length Frequency Distribution, Expressed in Percentage, of *Biyang Puti* from Taguig and Cardona, Rizal.
4. Monthly Length Frequency Distributions, Expressed in Percentage, of *Biyang Puti* from Taguig and Cardona, Rizal
5. Condition of Ovaries of *Biyang Puti* from Taguig and Cardona, Rizal, from September, 1958 through August, 1959
6. Frequency of Occurrence of the Most Common Food Items of 161 *Biyang Puti*

PLATES

1. Map of Laguna de Bay
2. *Glossogobius giurus* (Hamilton–Buchanan)
   Figure 1—Fingerling (Age O)
   Figure 2—Yearling (Age I)
   Figure 3—Adult (Age II)
3. Stages of Maturity of the Eggs of *Biyang Puti*

Map of Laguna de Bay
Shaded parts indicate municipalities where white goby collections were made.
PLATE 1

FIG. 1 - FINGERLING (AGE 0)
[illegible] MM. (STANDARD LENGTH)
X1

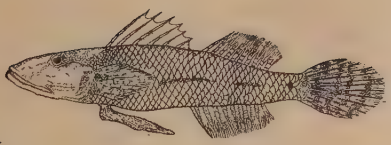


FIG. 2 - YEARLING (AGE I)
120 MM. (STANDARD LENGTH)
X1

FIG. 3 - ADULT (AGE II)
222 MM. (STANDARD LENGTH)
X - 95

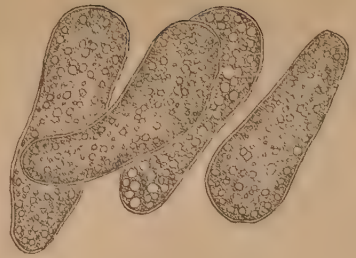
PLATE 2. *GLOSSOGOBIUS GIURUS* (BUCHANAN-HAMILTON)

STAGE 1: JUVENILE
X420

STAGE 2: QUIET
X128

STAGE 3: PREPARATION
X97

STAGE 4: FUSING
X238



STAGE 5: STRETCHING
X 109

STAGE 6: MATURE
X 116

PLATE 3- STAGES OF MATURITY OF THE EGGS OF BIYANG PUTI

LIMNOLOGICAL SURVEY OF LAGUNA DE BAY—A PILOT STUDY ON AQUATIC PRODUCTIVITY [1]

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Manila, Philippines

ONE TEXT FIGURE

ABSTRACT

A two-year survey of Laguna de Bay, the largest freshwater unit of the Philippines, has just been completed. As far as facilities could be available, the physico-chemical conditions, the biological characteristics, and the fisheries of the lake were investigated. Under UN/EPTA assistance, this work is being continued and will be expanded to cover other physico-chemical factors and the various trophic groups of living plants and animals participating in the food cycle. Present knowledge of this productivity relationships in this lake is discussed.

THE LAKE

Laguna de Bay, with an area of 90,000 hectares, is the largest body of freshwater in the Philippines. It is located in the lower third of the island of Luzon, bounded on the north by Rizal province and on the south, by Laguna province. On the average, it is slightly above sea level, being known to be at about 6 feet elevation. The lake water fluctuates during the year at an average range of two meters. Its water is supplied by an extensive watershed which pours into the lake through its several effluents. It has one outlet, the Pasig River, which flows into the Manila Bay.

The lake is extremely important to the economy of Laguna and Rizal provinces and vicinities. It is a source of fish for human food. About 80 million kilograms of fish valued at 25 million pesos are harvested from it each year.

At present, this lake is chiefly used as a source of animal feed, specially for the flourishing duck industry along the lake shores. For this purpose, a total of 240,000 tons of animal feeds, consisting mainly of snails, together with shrimps, fish, clams, aquatic plants and insects, are withdrawn from the lake each year.

[1] Contribution of the Philippine Delegation to the 11th Session, Indo-Pacific Fisheries Council, Kuala Lumpur, Malaysia, 1964.

The lake has become an institution, a medium of access and transportation to the twenty-eight populous towns along its shores. A small portion of its water is pumped to irrigate ricefields along its fringes. Some of the areas along its vicinities and within the lake are scenic and have been developed for recreation purposes and as summer resorts.

THE PROBLEMS

Significant changes in lake productivity of economic aquatic products and changes in lake conditions have long been noted by science workers, administrators and the people. The serious problems involved that need immediate solution are the following:

1. The depleted and/or declining condition of the fisheries and related problems of poverty, difficulties in enforcement of conservation regulations, etc.
2. Very rapid siltation in the lake with attendant shallowing and continuous turbid condition of the water.
3. Recurrent weed and algal decay problem.
4. The growing menace of pollution from industrial plants and population centers.
5. General lack of knowledge on the lake which holds the key for a rational solution of the above-listed problems.

THE PROGRAM

The clamor for a definite solution to the growing problems of Laguna de Bay culminated with the creation of the UN–assisted Freshwater Fisheries Investigations Unit (Limnology) of the Philippine Fisheries Commission at Barrio Bambang, Los Baños, Laguna. The program of the Unit has a two-point objective, namely:

1. To establish a continuing research program, designed to study the lake waters and their resources, isolate major problems and seek their solution.
2. To determine the characteristics and inter-relationships of the habitat, population and fisheries. Continuous measurement of these changes in the habitat, population and fisheries provides a sound basis for determining factors of abundance which is of course fundamental in making recommendations for the appropriate management of the resources.

To carry out these objectives, the Unit has put the necessary laboratories and the required organizational set-up of personnel. The personnel staff is divided into two sections, the Aquatic Resources Section and the Biology Section. The

Aquatic Resources Section evaluates the withdrawals and value of the various aquatic resources and assesses related economic factors, like fishing gear, boats used, fishermen, and the like. The Biology Section is divided into a Fisheries Group and a Limnology Group. The Fisheries Group takes up problems of fish population, biology and life history studies of fish and taxonomic studies; while the Limnology Group investigates hydrological aspects of the habitats as well as specialized studies on plankton, benthos, aquatic plants, and other non-fish resources.

The Unit also undertakes the training of limnologists and other freshwater fisheries workers. This is done by inservice training in the laboratory with quite a few through scholarships abroad.

The Unit has availed of the technical assistance of foreign limnology experts through UN/FAO aid. The experts have been charged with responsibilities to train the personnel, acquire equipment and seek foreign scholarships.

The Unit is at its third year of functional existence. A number of valuable data on the lake have been secured, some of which are reported in this paper. It is quite gratifying to note that the data obtained are giving much greater understanding on the conditions of the lake. Undoubtedly, the data will be useful for its proper management.

RESULTS OF STUDIES

Following the accepted thesis of biologists, we recognize *productivity* as the relative yield per unit time and space in terms of organic matter or energy in a given environment. The yield or product here can be in various forms and can best be recognized in terms of *trophic or production levels,* such as *primary producers* (the green plants and chemosynthetic bacteria), *plant or primary consumers* or *herbivores,* and a series of *secondary consumers, the carnivores.* The yield at each trophic level in terms of actual weights of organic matter produced is what we refer to as production at each specific level.

Status of Physical Factors Involved.—Laguna de Bay as a habitat for aquatic production possesses the following physical features: The confines of the lake of 90,000 hectares are uniformly shallow with an average depth of 2.5 meters. The estimated total volume of water in the lake is 2,700,000,000 cubic meters. This water is supplied by the 90 inches (229

centimeters) annual rainfall, and by the 210,000 hectares watershed which pours water into the lake through its effluents about 3,800,000,000 cubic meters per year. The lake level is constantly maintained by the corresponding removal of water to balance the additions from effluents and rainfall. These consist per year of about 1 billion cubic meters lost through evaporation. The coastline is quite regular but with big indentations, thus stretching it to a distance of over 200 kilometers. The bottom is uniformly muddy and rich in organic matter. The water temperature is typically high throughout the year, averaging 27.6°., fluctuating from 22°C. to 34°C. The lake water is normally turbid with a Secchi disc transparency average of 40 centimeters. Conductivity values for the lake water are high, averaging 1,300 micromhos (mho.).

Chemical Conditions Observed.—The lake is well supplied with dissolved oxygen at all depths throughout the year with an average of 8.5 parts per million (ppm). Free carbon dioxide is negligible and the pH ranges from near neutral to slightly alkaline, averaging 7.2. Total alkalinity values indicate an average of 115 ppm, while total hardness, 170 ppm. The chlorine content is relatively high but fluctuating and averaging 8 ppm. No nutrient analyses for nitrogen and phosphorous nor essential minerals have been made as yet in these first set of data.

Suspended Organic Matter—The Yield from Primary Producers.—No direct determination of the production of primary producers has been determined but an important segment of this trophic group may be deduced from the production of suspended organic matter in the lake. This mainly represents the plankton. Regular sampling of plankton is being conducted and results so far showed that the lake water has an average of 9.5 milligrams per cubic meter or equivalent to a standing crop of 25,000 kilograms at any one time in the entire lake to support the production of higher aquatic and economic organisms, such as fish, snails, shrimps, etc. While the above figure appears apparently small, it should be remembered that the organisms involved here are microscopic with inherent extremely rapid rate of replenishment or turnover.

Unfortunately, in connection with the evaluation of the entire primary producers in the lake, the value of higher aquatic plants (both submerged and emergent) has not yet been fully assessed.

Benthos Production.—Studies on the bottom organisms which compose one of the major trophic levels of organic production in the lake was continued and assessment was made of data accumulated for a three-year period, 1962–64. It was found that for this period the average standing crop of benthic forms amounts to 423 kilograms per hectare or equivalent to 38,070,000 kilograms for the entire lake. This consisted mainly of snails which accounted for 400 kilograms per hectare or 95%, midges (Chironomid larvae) 16 kilograms or 4% and annelids, 7 kilograms or 1%. Since there are differences in the type of lake bottom, significant variations occurred in amounts and kinds of benthos among different stations where the samples were taken.

From the above standing crop of benthos organisms of the lake, a surprisingly large amount of withdrawal is being made annually to fill the very high and increasing demand for feed of the duck raising industry around the lake. Special types of bottom dredges, commonly called snail dredges, because of their major catch, are used for this purpose. Data obtained for a two-year period (1962 and 1963) showed an average annual withdrawal of 244,042,000 kilograms or equivalent to 2,700 kilograms per hectare per year. These consisted of 150,888,500 kilograms or 62% snails; 16,134,000 kilograms or 3% clams; and 85,087,500 kilograms or 35% miscellaneous forms (shrimps, fish, insect larvae, and vegetative types). The above data show that the very high withdrawal of over 240 million kilograms each year is six times as much as the average standing crop of about 40 million of these benthic forms. It will show further that these forms must increase at very high replenishment rate to support this withdrawal or face extinction. The present characteristic withdrawal of small immature forms of snails and clams and even shrimps and fish is a bad sign for this trophic level, a problem which needs further study.

Shrimp Biology and Production.—Some observation on the biology of the dominant species of freshwater shrimps in the lake, the *Macrobrachium lanceifrons* Dana, were completed during the period. Spawning and larval development of this species were observed and it was found that spawning takes place all year round with each female spawner of sizes ranging from 30 to 55 mm. long, laying from 180 to 800 eggs per spawning.

Fairly large quantities of shrimps are being withdrawn from the lake for human food and for duck feed each year. For a two-year period (1962-1963), the average annual withdrawal with the use of three major shrimp-catching methods, brush shelter, motorized push net and manual push net, was 19,096,210 kilograms valued at ₱5,733,610. This harvest is equivalent to 219 kilograms per hectare per year from the lake.

Fish Biology and Production.—At least twenty-four species compose the fish fauna of this lake. The major bulk of the catch consists of the silver perch or *ayungin, Therapon plumbeus;* white goby or *biyang puti, Glossogobius giurus;* and land-locked catfish or *kanduli, Arius manilensis.* The perch and goby are most abundant although these are relatively small and are not very desirable. The catfish is a highly desired species and was once the major catch from this lake but it has continued to decline through the years. Other species indigenous in this lake are mudfish or *dalag, Ophicephatus striatus;* freshwater catfish or *hito, Clarias batrachus; dulong* or minute mirror goby: *Mirogobius lacustris,* and other species of gobies; and climbing perch or *martiniko, Anabas testudineus.* Some species have also been introduced and those established are the common carp, *Cyprinus carpio*; *Tilapia mossambica; plasalit, Trichogaster* spp; and *tawes, Puntius javanicus.* Sporadically, some saltwater species may come up the lake but serious pollution of the Pasig River has now greatly restricted their entrance. Milkfish fingerlings are regularly stocked since 1956 as a management measure to augment the fish population of the lake.

Studies on the biology of the major species have been made and work on feeding habits of *Therapon, Glossogobius* and *Arius* have been completed. Preliminary report on the biology of *Glossogobius* has also been finished.

The total catch estimate of the major fishing gears of Laguna de Bay was evaluated during the period from 1961-1963 and it was found that the overall production of fish during the period amounted to 82,881,595 kilograms, valued at ₱24,976,980.00. This is equivalent to a production of 920 kilograms per hectare per year, valued at about ₱280.00. The fishing gear used in this calculation includes fish corral or *baklad,* gill net or *pante,* drive-in-net or *seket,* motorized push net or *turo,* and drag seine or *pukot.* If the fish production

were included in the shrimp withdrawal of 210 kilograms per hectare per year a total of 1,130 kilograms of fish and shrimps may be withdrawn per hectare per year from the lake. It is apparent that the production is high but the monetary value of such production is relatively very low, which indicates either inferior quality products such as small types of fish less desirable species, or immature sizes of fish. This is confirmed by the fact that the unit price of fish and shrimps landed from Laguna de Bay is only ₱0.31 per kilogram. In spite of the apparent high yield per unit area of lake water (1,130 kg.) and the relatively satisfactory earning of the fishermen estimated at about ₱1,900.00 per year per fisherman, or a monthly income of ₱150.00, the present diagnostic characteristics of the lake fisheries have varied indications that, unless drastic steps are taken to regulate withdrawal of fishery resources in the lake, coupled with positive measures, such as periodic stocking, the lake resources will continue to be rapidly depleted.

The Role of Ducks and Man.—The major portion of the lake production is channeled to feed ducks. Duck raising for eggs is an established industry along the shores of this lake. From it, some 245,000 metric tons of feed materials are derived per year to support the duck industry, consisting of snails, shrimps, fish, clams, and aquatic vegetative matter and insect forms. At the end of 1963, there were 4,324 duck farms with a duck population of 516,980. These were producing 219,300 eggs per day or a net production of 80 million eggs per year.

Man exploits the fisheries of the lake. There are some 13,000 full-time fishermen upon whom 55,000 people directly and 500,000 indirectly depend for their livelihood from the lake fisheries. Also, the entire population of Rizal and Laguna provinces and Manila and suburbs, totalling some 3 million people, in some way or other, derive some advantages from this lake.

There are 41 types of fishing gear operating in Laguna de Bay, totalling 9,520 units of which 5,650 or 60% operate the whole year round; 3,462 or 35% operate for 6 to 10 months, and 408 or 5%, in less than six months. The most important gears are fish corral or *baklad*, seine or *pukot*, gill net or *pante*, drive-in-net or *seket*, mechanized push net or *turo*, scoop net or *salap*, shrimp brush shelter or *bonbon ng hipon* and snail

dredge or *kaladkad suso*. The fishing operations involve 7,149 boats of which 2,599 or 35% are motorized while 4,590 or 65% are nonmotorized.

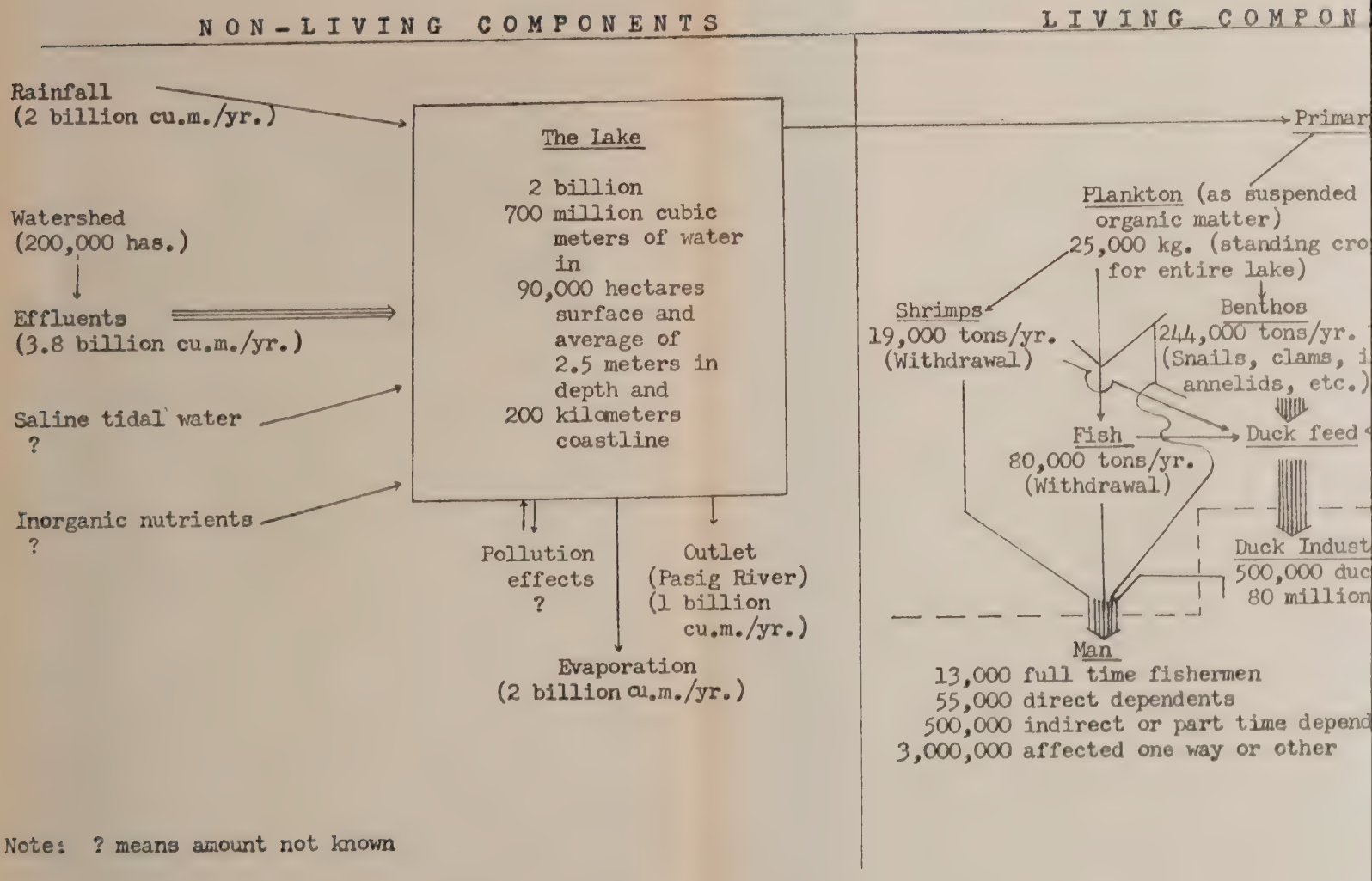
The Lake Food Chain (See Figure 1).—There is a number of non-living influences that greatly affect the lake. These include: (1) the 200,000 hectares watershed pouring 3.8 billion cubic meters of water per year through effluents into the lake, (2) 90 inches (228.6 centimeters) of annual rainfall, (3) saline tidal water of unknown quantity and inorganic nutrients coming in with the effluents and other sources, (4) pollution which acts two-ways—destructive or enrichment, and (5) actual removal through Pasig River outlet and natural evaporation. All these contribute to the make-up of Laguna de Bay as a physical environment for the production of aquatic organisms.

Biological production in this lake is started off by the primary producers, the green plants, which consist of two main forms—the microscopic suspended forms or plankton and the higher aquatic plants of various types. The suspended forms have a standing crop of 25,000 kilograms which is probably rapidly being replenished. The rate of use of these forms by higher trophic levels and rate of turnover will need further study. An estimate of the biomass of higher aquatic plants has not been made but a part that was used in the food chain has been evaluated to be about 10,000 tons per year. These are probably the submerged soft types collected by dredges while the emergent and fringing hard forms are probably more of a liability in the chain of production in the lake.

The suspended forms support the production of shrimps, fish and benthos. The benthos production, mainly of snails, is about 420 kilograms per hectare per year; shrimps, 120 kilograms, and fish, 920 kilograms.

Almost all of the benthic (mainly snails) and a major part of the shrimps and fish production are funneled to support the extensive duck population of over 500,000 along the lake shores. Raised in 4,000 duck farms, these form the source of 80 million eggs per year.

A selected portion of withdrawn fish, shrimps and mollusks from the lake is used for human food. This is exploited by 13,000 full-time fishermen with 55,000 direct and 500,000 indirect dependents. Three million people from the most populous region of the Philippines also derive some form of advantage from the lake.



Note: ? means amount not known

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CONCLUSIONS AND RECOMMENDATIONS

1. The results obtained by the Laguna de Bay Limnology Project, although still fragmentary, are giving a much clearer picture of the conditions of the lake. To be conclusive and effective as tools for the management of the lake, these studies should be continued and expanded.

2. A very serious problem of the lake is the rapid siltation from the surrounding watershed leading to the accelerated geological aging of the lake and continuous turbid condition of its waters. Protection and conservation of the watershed will help prevent the fast extinction of this lake.

3. Luxuriant growth of various higher aquatic vegetation and recurrent seasonal algal blooms are also serious problems of this lake. Softer aquatic weeds and algae may be reduced by the introduction and modification of the existing fish population in the lake.

4. To carry out more effectively the program of fish introduction and stocking, more fish culture and hatchery projects should be established and encouraged around the lake.

5. Experience in this area showed that enforcement of fishery regulations designed to conserve the fisheries is extremely difficult, especially in impoverished fishermen communities. Positive measures instead of regulations may produce better results. Fish stocking, introductions, environmental improvements, etc., may be initiated.

6. The land-locked catfish or *kanduli* poses a question as to whether its conservation should be continued or scrapped altogether. It is a highly desirable species, but a very vulnerable one, laying few big eggs each time and incubating them in its mouth. At present, this fish is still being conserved but the question of conserving *kanduli* needs further study.

7. A less radical conservation measure for the lake fisheries is to designate certain strategic areas as fish sanctuaries. There are evidences that the lake shore communities will support this. One of the municipalities has already petitioned for this measure to be applied in its area (Siniloan, Laguna).

8. Industrial plants have been and are being established along the lake shores or near some of its effluents. Likewise, the towns and villages have grown and are dumping greater amounts of wastes into the lake. For this lake to continue producing fishery resources at maximum levels and of desirable quality, the dangers of pollution should be minimized and/or regulated.

ILLUSTRATION

TEXT FIGURE

FIG. 1. Limnological survey of Laguna de Bay.

NOTES ON THE INFESTATION OF CHANOS CHANOS BY A PARASITIC ISOPOD

By Inocencio A. Ronquillo and Priscilla Caces-Borja
Of the Philippine Fisheries Commission

ONE TEXT FIGURE

The occurrence of infestation of parasitic isopods in brackish water ponds for bañgos (*Chanos chanos* Forskal) has been noted in Central Luzon.

Sometime during the rainy season in 1958, attention was called to the occurrence of swarms of crustacean ectoparasites in a bañgos fishpond in Dampalit, Malabon, Rizal. A few specimens were submitted to this Office, and review of literature, revealed that they were isopods.

In 1962, an infestation was reported by the District Fishery Officer of Pangasinan in bañgos fishponds in Binmaley, Pangasinan. The parasite was first observed just after the floods caused by Typhoon Kate, one of the worst that struck Luzon sometime in August, 1962. Specimens were collected by fishpond caretakers and were sent to this Office but were not saved. Some observations were made of the salinity which was at zero and the water temperature at 31.5°C.

The third report was made by Mr. Roman Abalos of Maligaya Experimental Station, Muñoz, Nueva Ecija, who brought 28 specimens, ranging from 7.0 to 10.0 mm. in length, also from Binmaley, Pangasinan, collected on October 21, 1962.

The ectoparasite appears when the salinity of the water is very low and the appearance is sporadic but once the pond is infected, great quantities are found at any one time. The infestation is so bad that the irritated fish loses much energy in moving about to shake off the parasites, so they have to be harvested and disposed off even when small. The fishpond caretakers who go into the infested ponds are also irritated by the great number that cling to their bare legs.

Another incidence of the ectoparasite was reported in 1963 from Parañaque, Rizal.

The fifth report was made by Felipe A. Maclang of the Shell Chemical Company who brought 79 specimens of the ectoparasite to our attention, informing us of the control they had developed which they claimed to be effective. We have not tried the same as no new occurrences have been reported. The specimens were also taken from Binmaley, Pangasinan, July

Parasitic ISOPOD on *Chanos chanos*

Taxonomy—

Class—Crustacea
Subclass—Malacostraca
Order—Isopoda
Suborder—Flabellifera
Family—Cymothoidae
Subfamily—Cymothoinae

25, 1964, and collected by Mr. Lazaro Tañedo. Likewise, the collection was made during the rainy season. Of the incidents here reported, three were from the Agno River basin and two from the Manila Bay area. It is possible that, as reported by Sachlan (1952) in his "Nqtes on Parasites of Freshwater Fishes in Indonesia," this is a related isopod in freshwater.

Previous reports (Sachlan, *op. cit.*) stated that the isopod (*Ichthyoxenus jellinghausii*) infects various carps and other river fish but not cultured fish. As far as we know, this is the first record of the ectoparasite (isopod) attacking *Chanos chanos*, the most important pond fish in the Philippines. The

fact that it is very destructive once infection starts, requires utmost diligence to prevent the spread of this ectoparasite.

When a pond is heavily infected, the fish thereat undergo a peculiar uneasiness in view of the irritation brought about by the great number of the parasites. The parasites normally stayed near the pond bottom and were found to attach to any object, especially moving ones. They were observed to attach themselves even to humans. Other species of fish like the *Gerres,* eels, slipmouths, mullets, tilapia, gobies, and tarpons were also found to have this parasite attached to the bases of the fins, to the head, to the gills and membrane underneath the operculum and at the vent.

A brief description of the animal follows.—It has a somewhat oval body with 13 segments including the shield-like telson; triangular head with two pairs of segmented antennae, the first with 7 very short cylindrical segments about 1/4 the length of the 2nd and the second with about 15 cylindrical segments. The head has a pair of large, faceted eyes.

The body is provided with 7 pairs of walking legs (pereiopods) provided with hooks, 4 pairs of swimmerets (pleiopods) and 1 pair of uropods.

The width is about 2.5 mm. in length.

Upon dissection, the biggest ones (10 mm. long) showed developing ovaries at the region of the 3rd and 4th pairs of walking legs. No sign of a brood pouch was visible. A smaller specimen was also dissected and it showed 3 locules of testes transforming into the ovary. It appeared that the specimens were still young but were in the process of transforming into the female sex.

In view of the rare and sporadic occurrences of the parasite, no detailed study has been made on its life history, inasmuch as the attention of the fisheries officials are called only when infestation is so severe, and when the fish are already harvested and disposed of. In view thereof, no description of the infected fish could be included in this report.

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ILLUSTRATION

TEXT FIGURE

FIG. 1. Parasitic isopod on chanos chanos.

NOTES ON A RARE CASE OF TURTLE POISONING

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ABSTRACT

A rare case of turtle poisoning which occurred in a Muslim community at Cotabato, Mindanao, is reported. The meat, eggs and entrails of a sea turtle normally found in the locality were boiled and eaten, after which 11 individuals, as well as dogs, who ate the entrails died. Description of the turtle thru letters showed that its possible species is *Eretmochelys imbricata*, the hawksbill turtle. Although a previous case of poisoning was reported from a nearby locality, yet no accurate data were taken for comparison.

The symptoms noted showed the neurotoxic action of the poison which was similar to other cases previously reported in the literature. The epithelium of the buccal cavity was severely affected.

Samples of the turtle meat were salted and sent to the Manila Health Office for analysis, but it failed to show the symptoms of poisoning when fed to rats.

A review of literature of cases of turtle poisoning was made. A previous case in Cebu, Philippines (1917) was cited although Taylor (1921) believed that it was the green turtle, *Chelonia mydas* L. which caused the poisoning. The symptoms exhibited in these two Philippine cases were more or less identical.

This paper is a report on a rare case of turtle poisoning which occurred in Rosa community, Dinaig, Cotabato, Philippines.

On February 5, 1954, there was a gathering of Tirrurays, a Moslem community in Barrio Rosa, Dinaig, Cotabato, in connection with spiritual rites for a deceased. In this celebration, the guests, including their dogs, were served with meat, eggs and entrails of a sea-turtle, commonly eaten in said locality and known as *payukan*. The local name for this turtle is hawkbill turtle, *Eretmochelys imbricata* Pennant. The turtle's meat was prepared in the usual way as used by the natives wherein pieces of meat were boiled. Of the people who partook of this boiled turtle's meat, a total of 11 individuals, eight males and three females, died. Likewise, many dogs, which ate the entrails of the turtle, died also.

The approximate carapace size of the turtle was about one meter in length and about 61 cm. in width. As described (per comm.), this turtle had thin scutes which indicated that it had been previously caught while still young, its scutes having been removed and then thrown back into the sea, because it is locally believed that it would develop another set of scutes. The scutes of this turtle are commonly known as the *tortoise shells of commerce*, and it is the common practice in the locality to return the tortoise to the sea after removing the scutes by heating the carapace over the fire until the shell is loosened.

In another adjacent community in Kimini, Cotabato, the same kind of turtle, with a new growth of scutes, had caused a similar poisoning during the same season. Inasmuch as this is the only turtle wherein scutes are removed for commercial purposes, we believe that the identity of the species is, more or less, accurate. Furthermore, the egg diameter (2.5 to 3 cm.) is the normal size of this turtle.

Symptoms.—A few hours after partaking of the cooked meat, the victims complained of hot sensations at the region of the abdomen, accompanied by cold sensations at the extremities. A strong feeling of nausea ensued which caused some of the victims to vomit a portion of the food they ate. This condition persisted until the following day when dizziness then set in, accompanied by degeneration of the sense of balance, together with blurred vision and a feeling of sleepiness. To some of the victims, vomiting and diarrhea had been very severe. After 3 to 4 days in this condition, the mucous membrane of the mouth and throat of the victims became red and swollen, becoming sore later. These membranes assumed the appearance of having been scalded with hot water. The tongue, particularly, became heavily coated with a whitish membrane. Because of this condition of the mouth, throat, and tongue, the victims had extreme difficulty in eating and even in drinking. Some patients complained of frequent urination of highly colored urine. Of the victims who partook of the feast, six children, ranging from 1½ to 4 years old, one young man, aged 35, and three older people, 50 to 60 years old, died.

Eight days after the poisoning, the District Health Officer of Cotabato, who was called to attend to the cases, advised the patients to gargle warm water with normal saline solution to prevent further infections of the mouth.

Those who were still alive at the time were very weak and were given a liquid diet of boiled rice, and tea or coffee. Those

who were seriously ill were given muscular injections of caffein and sodium benzoate.

The Health Officer sent samples of the turtle meat to the Manila Health Office for analysis. Furthermore, he gave the clinical data for which we are greatly indebted. The meat was fed to laboratory rats, but these did not show any symptoms of poisoning. The meat was heavily salted and dried. However, it was washed to remove most of the salt before boiling in water. Both meat and water were given to the animals. Reports from the Public Health Research Laboratories, Manila, indicated negative results as far as active ingredients were concerned, Rats fed with the meat, which was boiled after washing, were not affected at all. It is possible that the salt used to preserve the meat might have destroyed the poisonous nature of the flesh.

This information was verified by the Municipal Health Officer of Cotabato.

Inquiries made in Zamboanga City indicated that there is no known case of turtle poisoning in that City where green turtles (*Chelonia mydas*, L.) are butchered regularly throughout the year. The Muslim population there relish the meat of this reptile without any mental reservation. That no reported case of turtle poisoning in that city where a lot of marine turtles are being butchered more than in any other part of the Philippines is therefore interesting.

Review of Literature:

The earliest record of turtle poisoning was from the New World. It took place at Saint Jacques, Windward Islands, North America, way back in 1697, as reported by the monks, Damplier and R. P. Labat, in 1724. Labat stated that Jean Montididier, also a monk, bought a tortoise plastron of probably *Eretmochelys imbricata* Pennant, and in spite of his warning, ate as much as he could, As a result, after four days, he was covered with boils. These were accompanied by a terrible diarrhea and high fever for which he suffered for eighteen to twenty days. Father Labat himself, who took caution in partaking of the turtle's meat, had a little diarrhea for six days, accompanied by three boils.

Cleland, sometime in 1845–47, cited from Banfield's "Confession of a Beachcomber" that in some localities in northern Queensland, Australia, the flesh of the hawksbill turtle, *Eretmochelys imbricata* is said to be imbued with a deadly poison,

so that care should be exercised in the killing and butchering of this animal, lest a certain gland, located in the neck, be opened. The poison is so toxic that flesh cut with a knife which has touched the critical part, becomes impregnated with the poison. One old seafarer acknowledged that he nearly "pegged out" after a hearty meal of the liver of the hawksbill.

"Banfield also states that the flesh of the luth or leathery turtle, *Dermochelys coriacea*, also causes symptoms of poisoning.

Chevellier and Duchesne (1851) reported that the hawksbill turtle, *Eretmochelys imbricata*, is not good to eat; that it has a special purgative quality according to Damplier and Labat, (*op. cit.*), and that, when eaten, one may be "certain of being covered with boils," if there are some impurities in the body. But if eaten sparingly, the flesh can cure some diseases. When the flesh of this turtle is salted, it loses its purgative effect,

Tennent (1861) reported that the flesh of sea turtles caught in the southwest coast of Ceylon during certain seasons is avoided because they are poisonous. Tennent cited a case of poisoning at Pantura, near Colombo, Ceylon, where in October, 1840, twenty eight persons who partook of a sea turtle were seized with sickness immediately after which a coma supervened and 18 died during the night. Those who survived related later that the flesh of the turtle was fatter than that of the ordinary. He also stated that similar fatal occurrences had been attributed to turtle curry, although there was room for believing that the poison might have been contained in some other ingredients.

The first Philippine report on turtle poisoning was made by Taylor (1921) and cited that the turtle alluded to in Sir Tennent's report (*op. cit.*) was a *Chelonia virgata* [*Chelonia japonica* (Thunb.)]=*Chelonia mydas* (Linnaeus). Taylor (*op. cit.*) cited a case of turtle poisoning in the Philippines, presumably by *Chelonia mydas*. It occured in November, 1917, in Bantayan Island near Cebu. Fourteen deaths were reported out of 33 cases. The victims suffered from pain in the throat and lips vomiting, and drowsiness. Two of those who died had their symptoms very much delayed, coming out after 8 days of partaking of the turtle's meat. Nevertheless, they had symptoms of poisoning similar to those who died earlier and they died after 6 days. It was also reported that relapse in this case occurred even after cure had set in. The

tendency to drowsiness from the moment symptoms appeared was also manifested, and even if improvement under treatment appeared later, still the victims died. It was noted that there is a great similarity of symptoms between the poisoning of 1917 in Bantayan Island and that of the present case. Read (1917) had scattered references to turtle poisoning but without proper identification of the real species.

The similarity of these two recorded cases of turtle poisoning in the Philippines indicates a strong credence that there is really a poisonous substance at times in the meat of some sea turtles which are caught in the Philippines that causes death, although the particular species is not clearly verified in all cases.

It should be noted that like the report of Chevellier and Duchesne in 1851, the flesh of the poisonous turtle, when salted, loses the purgative effect. The flesh of the turtle in the present case showed the same findings when a piece of its meat was sent to the Public Health Research Laboratories in Manila for analysis, just as a sample of meat from the 1917 poisoning was also sent in for examination. In both cases, the meat was heavily salted and dried, and the examination of the flesh failed to reveal the presence of any known poison.

It was noted that, inasmuch as the diarrhea following the eating of turtle's meat had a very dehydrating effect, most of the victims who died in the present case were both young and old. Although one of the dead was 25 years old, this supported the observations of Chevellier and Duchesne: "It is necessary to be of strong, robust nature to resist this evacuation." That the flesh samples delivered at the Government Laboratory in Manila did not have any trace of poison or any effect on experiment rats may be answered from the report of Chevellier and Duchesne (1851) that, if the flesh of the hawksbill turtle has been salted, the purgative effects of poison are lost.

Deraniyagala (1939) noted that the flesh of the leather back turtle, *Dermochelys sp.*, is also reported to possess faintly toxic properties during some seasons when taken on the east coast.

From the review of the literature, it is more or less, concluded that the sea turtle which caused the mass poisoning in Barrio Rosa, Municipality of Dinaig, province of Cotabato, is of the spicies *Eretmochelys imbricata.*

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